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APPLIED MECHANICS Reviews

A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS AND RELATED ENGINEERING SCIENCE

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APPLIED MECHANICS REVIEWS

VOL. 6, NO. 6 MARTIN GOLAND Editor JUNE 1953

DISPERSION OF SALTS INJECTED INTO LARGE PIPES OR THE BLOOD VESSELS OF ANIMALS

G. I. TAYLOR

CAMBRIDGE UNIVERSITY, ENGLAND

ONE OF the methods which has been used by physiologists[1] to measure the velocity of the blood stream in the veins or arteries of living animals is to inject a highly conducting fluid at one point and to measure the changes in conductivity at some place downstream. The electrical conductivity at the downstream point rises as the conducting fluid passes over it, and the time interval between injection and this rise in conductivity is measured. The same method has been used on a much larger scale to measure the flow into large hydroelectric power stations.

If the injected material would remain concentrated in a small volume, the time interval between injection and the consequent sudden increase in conductivity downstream would determine the speed of flow, but the variation in fluid velocity over the cross section of an artery or pipe will cause different parts of the injected material to arrive at the measuring point at different times. The conductivity-time curve at a downstream station can therefore be used only for flow measurement if a decision can be made as to which point on this curve corresponds with the mean velocity in the pipe. In the case of large water mains this question has been treated experimentally by Allen and Taylor.[2] Using a 40-in. pipe 355 ft long, these authors found that the point on their conductivity-time curve which corresponded with the mean flow (as measured by other methods) was closely that at which conductivity reached its maximum value. One set of their measurements is here reproduced, Fig. 1. It will be seen that the curves are nearly but not quite symmetrical, and that the time during which the conductivity is above its normal value (about 30 sec) is much longer than the one or two seconds taken to inject the salt into the pipe. In fact, this time is of the same order as the 104 sec in which the mean speed carries the salt 355 ft. In other words, the rear end of the column of salt solution travels more slowly than the front. The authors do not discuss the theoretical implications of their measurements; in fact, in the only place where they attempt to use theory to interpret them they seem to have been led astray, for they state (op. cit., p. 314): "Theoretically the center of gravity of the salt charge *which is indicated on the chart* (the conductivity-time curve) *by the center of gravity of the area enclosed by the curve*, is the correct point from which to compute the time." The words in italics would be true only if the fluid velocity were the same at all points of each cross section. The salt in any part of the fluid which travels more slowly than the mean will make a bigger contribution to the area of concentration-time curve than the same amount of salt in places where the stream velocity is higher. On the other hand, if the word "theoretically" is omitted, the sentence quoted may be a useful summing-up of experimental results.

Though it is not possible to give a complete picture of the dispersion of salt in turbulent pipe flow, one can analyze what happens when a salt is introduced into a small tube containing a viscous fluid in nonturbulent flow (the physiologist's problem), and

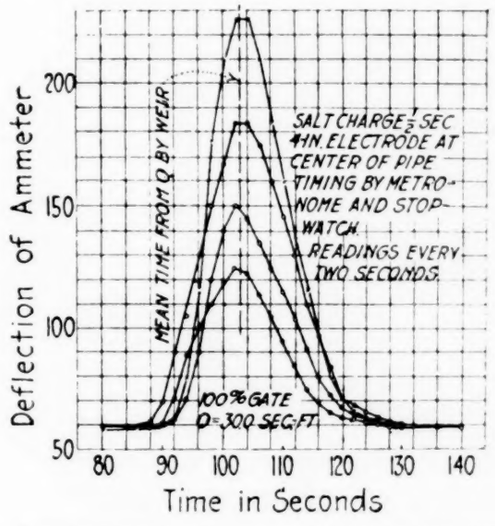

FIG. 1 CONDUCTIVITY-TIME CURVES 355 FT FROM INJECTION POINT IN 40-IN. PIPE

(Reproduced from Fig. 5 in Allen and Taylor's paper; see footnote 2.)

[1] H. L. White, *American Journal of Physiology*, vol. 151, 1947, p. 45.

[2] "Salt velocity methods of water measurement," C. M. Allen and E. A. Taylor, *Transactions of The American Society of Mechanical Engineers*, no. 1902, vol. 45, 1923, p. 285.

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the conclusions attained in that case seem to have a bearing on the large-scale phenomena described by Allen and Taylor. The results of my investigations on this subject have not yet been published, but I can set down without proof those which seem relevant to the engineering application. These are:

1 The distribution of salt is controlled by the joint action of molecular diffusion in a radial direction and convection along the pipe due to variation of velocity over the cross section.

2 Salt which is initially concentrated at time $t = 0$ at a section $x = 0$ is later dispersed along the tube in such a way that the mean concentration C over the cross section at a point x at time t is

$$C = \frac{A}{\sqrt{t}} e^{\frac{-(x-Ut)^2}{4Kt}} \qquad [1]$$

Here U is the mean velocity of the fluid which, in the case of nonturbulent flow, is necessarily half the maximum speed in the middle of the pipe. A is a constant depending only on the total amount of salt introduced. K is a constant whose value I find to be

$$K = \frac{a^2U^2}{48\,D} \qquad [2]$$

where D is the coefficient of molecular diffusion and a is the radius of the pipe.

Several interesting deductions can be made from Equations [1] and [2].

(a) The salt is distributed along the pipe according to the error law, and the center of this distribution is at a point which moves downstream with the mean velocity of flow.

(b) The dispersion from this point is symmetrical so that, at a given instant, C is symmetrically distributed about the point $x = Ut$. This is surprising because the variation in velocity over the section, which is responsible for the dispersion, is highly unsymmetrical. This theoretical prediction is conclusively verified experimentally. Fig. 2 shows measurements of the distribution of a concentration of potassium permanganate after being carried 110 cm down a glass tube of $^1/_2$-mm bore in 660 sec. An error curve is also shown to illustrate the accuracy with which Equation [1] represents the dispersion. It is worth mentioning that when K is determined from Equation [1] using the value 121, which fits the observed points, for $4Kt$; and when this value is inserted in Equation [2], together with the measured values of U and a, the resulting value of the molecular diffusion D comes out as 0.8×10^{-5} in cgs units. This is very close to the value given in physical tables.

(c) Though the distribution in space is symmetrical at any time, the concentration-time curve at any fixed point is not. It is found, however, that if the length of the zone of dispersion in the pipe (approximately $4\sqrt{Kt}$) is considerably smaller than $x = Ut$, the degree of asymmetry of the concentration-time curve is small.

(d) The dispersion is the same as though the fluid had a virtual coefficient of longitudinal diffusion K. It will be seen from [2] that K is small when a or U is small and D is large. Thus, in a small bore tube through which the flow is very slow, the salt moves almost without dispersion. The molecular diffusion in the transverse direction in fact moderates the dispersive effect of the variation of velocity over the section of the pipe.

Comparing these results (a), (b), (c), (d) with those of Allen and Taylor for turbulent flow:

(a) Inspection of Fig. 1 shows that the observed distributions of concentration are very like error curves, and the points of maximum concentration move with the mean speed of flow.

(b), (c) The experimental concentration-time curves are slightly unsymmetrical in the same sense that the theoretical expression [1] is unsymmetrical with respect to t; that is, the area of curve before the attainment of maximum concentration is rather less than the area after that instant. The degree of asymmetry in the observed curves appears to be rather greater than that represented by Equation [1].

(d) It is not possible from Allen and Taylor's published observations to say whether the maximum concentration will decrease along a pipe as $1/\sqrt{x}$ and the length of the dispersed

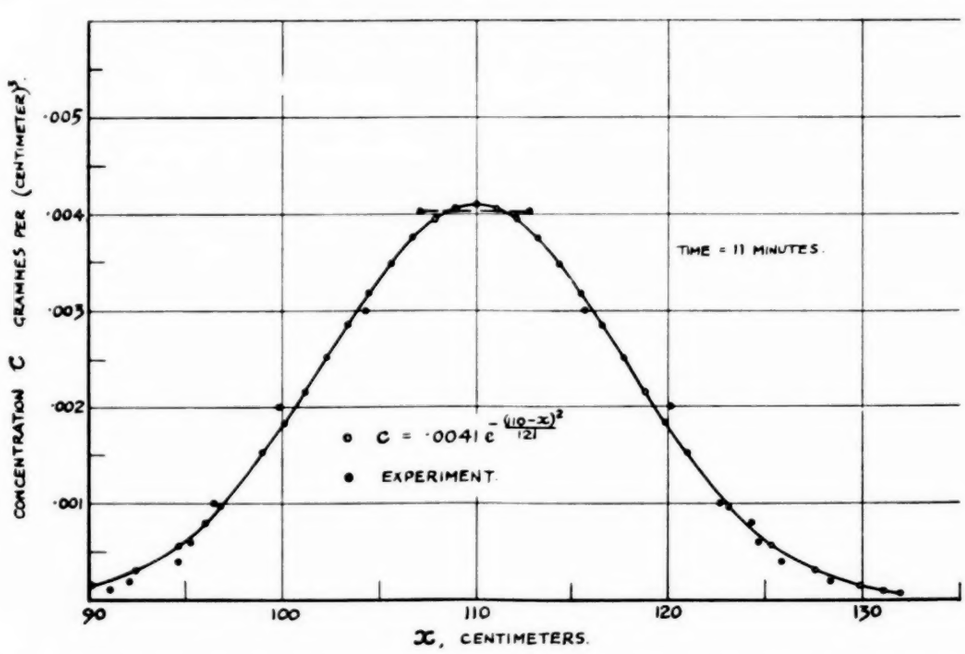

FIG. 2 CONCENTRATION OF POTASSIUM PERMANGANATE IN A TUBE AFTER BEING SWEPT 110 CM IN 11 MIN IN A TUBE $^1/_2$-MM BORE. CONCENTRATION C EXPRESSED AS PROPORTION BY WEIGHT OF PERMANGANATE

column increase as $\sqrt{x}$. This is the prediction made in Equation [1], and it was verified experimentally in my experiment with nonturbulent flow in glass tubes of small bore. It would be interesting to make the appropriate measurements in a long pipe of larger diameter.

If the formula [1] could be applied to turbulent flow, error curves could be fitted to those shown in Fig. 1. Performing this operation roughly, I find that Allen and Taylor's observations shown in Fig. 1 correspond with a value $K = 2.2 \times 10^3$ in cgs units. Since the dimensions of K are L^2T^{-1}, it may be convenient to express K as a multiple of aU. In this way, one might deduce that the dispersion of salt in a large pipe relative to a point moving with the mean flow can be regarded as being due to a virtual coefficient of diffusion equal to

$$K = 0.4\, aU \qquad [3]$$

The factor 0.4 is simply 2.2×10^3 divided by $a = 20$ in. $= 50.8$ cm, and by $U = (355 \text{ ft}/104 \text{ sec}) = 104$ cm per sec.

Using the universal expression for the distribution of velocity u with radial coordinate r in the form

$$\frac{u - U}{v_*} = f\left(\frac{r}{a}\right) \qquad [4]$$

where $v_*^2 = \tau_o/\rho$, and τ_o the friction per unit area of surface of the pipe, and applying the Reynolds analogy between turbulent diffusion and turbulent stress, I find, after some calculation, the expression

$$K = 8.98\, av_* \qquad [5]$$

This expression is identical with [3] if

$$U = \frac{8.98}{0.4} v_* = 22.4\, v_*$$

This is, in fact, a very reasonable value for a 40-in. pipe. It corresponds with surface drag $\tau_o = 0.002\, \rho\, U^2$.

Communications

Concerning Feature Article, AMR 5 (August 1952): M. M. Frocht, The growth and present state of three-dimensional photoelasticity.

In regard to my article, an interesting letter was recently received from Dr.-Ing. Albrecht Kuske in Germany.

As he points out, his doctor's thesis, published in May 1938, describes his pioneering work on the freezing method. In this thesis he reports on his fundamental experiments with Bakelite and explains the phenomenon of frozen stresses by the diphase theory of plastics. Credit for this work and explanation should go to him.

He was also the first to publish the suggestion to supplement the optical measurements from slices containing frozen stresses with mechanical measurements of deformations after annealing ["Das Kunstharz Phenolformaldehyd in der Spannungsoptik," *Forsh. Geb. Ing.-Wes.* **9**, 3, May 1938].

It also seems that Dr. Kuske was among the first to use laminated models for the study of stresses in plates in transverse bending.

I regret that these points were omitted from my recent survey of three-dimensional photoelasticity, and I am grateful to Dr. Kuske for calling my attention to them.

I also note with interest that a new castable plastic suitable for two- and three-dimensional photoelasticity, called Geissharz P, is now available in Germany and can be obtained from the Badische Anilin und Sodafabrik, Ludwigshafen a.Rh., Germany.

M. M. Frocht, USA

Concerning AMR 5, Rev. 3450 (December 1952): A. L. Jorissen and H. T. Newton, Discharge measurements by means of cylindrical nozzles.

Review contains the statement: "However, the comparison is not as favorable as implied, since the authors use a Reynolds number that is based on inlet conditions, while the ASME report (their Ref. 1) used a Reynolds number that was based on the throat section."

At a meeting held in Paris in 1948, Technical Committee no. 30 of the International Standardizing Organization (ISO/TC 30) on the Measurement of Fluid Flow decided to adopt the pipe Reynolds number universally. The ASME Research Committee on Fluid Meters is now revising all experimental data in order to analyze discharge coefficients in function of pipe Reynolds numbers. This procedure will be followed in the new edition of "Fluid meters" now in preparation and in the revised edition of part 5, chapter 4, of the Power Test Code on Measurement of Quantity of Materials.

The figures given in the second paragraph of the introduction of the paper applied to pipe Reynolds numbers and establish without ambiguity the exact nature of the advantage of cylindrical nozzles for flow measurement at low Reynolds numbers.

A. L. Jorissen, USA

Concerning AMR 6, Rev. 352 (February 1953): N. L. Kusters and W. J. M. Moore, A generalization of the frequency response method for the study of feed-back control systems.

The paper does not, as is stated, "develop a method for determining the degree of stability of a servomechanism of which the transient response is known," but rather it gives "a method of determining directly the closed-loop transient response of a feedback control system from the logarithmic plot of its open-loop frequency response. The method consists generally of plotting the log-magnitude and phase curves of the open-loop function against the log of the complex variable $|s|$, for values of S along various axes radiating from the origin of the S-plane, instead of just along the imaginary axis as has been previously done. $\{S = u[-\zeta \pm j(1 - \zeta^2)^{1/2}]$, where $\zeta = \sin \alpha =$ damping factor, and α is the angle between imaginary axis and the axis of interest$\}$.

"The method may be used to obtain the gain of a feed-back control system for a predetermined damping factor of a conjugate complex pair, or, for a given gain, the values of the poles of the closed-loop function can easily be obtained. Formulas are derived which give the coefficients of real and complex unique roots as functions of the slope of the response curve and of the Laplace transform of the input. The method is illustrated on two examples, and it is shown how it may be used for a study of frequency-response diagrams in general."

The reviewer is in agreement with these remarks.

N. L. Kusters and W. J. M. Moore, Canada

Concerning AMR 6, Rev. 529 (February 1953): A. L. Jorissen, Discharge coefficients of Herschel-type Venturi tubes.

My review contains the statement: "It is unfortunate that . . . no definition is given for his Reynolds number. There is no way of determining from the paper whether the Reynolds number is based on inlet or throat conditions."

The reviewer failed to note the defining sentence in the middle of the first column on p. 906. This statement reads as follows: "All Reynolds numbers are expressed in functions of the pipe

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diameter, according to what will be from now on standard practice."

This confusion would not have resulted if the symbol representation of the Reynolds number had been included on the graphs.

G. N. Cox, USA

Theoretical and Experimental Methods

(See also Revs. 1806, 1807, 1830, 1831, 1838, 1915, 1968, 2022, 2031, 2065, 2097)

1789. Sedov, L. I., Similarity and dimensional methods in mechanics [**Metodí podobiya i razmiernosti v mekhanike**], Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1951, 195 pp.

In technical schools comparatively little attention is paid, as a rule, to dimensional analysis, theory of physical similarity and of mechanical models. Engineers usually cannot fully appreciate the great possibilities presented by this important branch of science. Many advanced questions of hydro- and aeromechanics hardly can be solved without using mentioned methods, and some problems of turbulence cannot be treated in any other way, for we do not know a complete system of equations governing the pertinent processes.

In its four chapters, Sedov's book presents the theoretical foundations for numerous applications of dimensional analysis and physical similarity. First section explains theory; the other three chapters are devoted to various technical applications from different branches of engineering, chiefly from mechanics of fluids and gases. Expressly noticed are problems on steady and nonsteady motions of fluids, study of shocks to water, small waves on fluid surface, treating of equations for motion of viscous fluids, questions about boundary layer, problems of turbulence, etc. The last chapter discusses some special facts about unsteady motion of gases.

The work is recommended to engineers and physicists as a useful handbook. V. Vodička, Czechoslovakia

1790. Shilov, G. E., Introduction to the theory of linear spaces [**Vvedeniye v teorii lineiníkh prostranstv**], Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1952, 384 pp.

Book is intended for students of Russian universities, but it is written in a way which makes its reading possible by all engineers. Besides the real theory of abstract spaces, now becoming more and more significant in various branches of applied mathematics and technical science (differential and integral equations, calculus of variations, etc.), the book under consideration also treats other important questions very successfully in its 14 chapters.

The first three sections explain the theory of determinants, matrixes, and show its use for solving sets of linear algebraic equations. Then come (chapters 4–6) considerations about linear, bilinear, and quadratic forms; sections 7–11 are devoted to the study of Euclidean spaces and to various applications of the associated facts (general discussion of the orthogonalization process, theory of characteristic vectors and eigenvalues, elements of analytical geometry in n-dimensional spaces, etc.). Chapter 12 studies normalized and metric spaces; section 13 concerns theory of Fourier series, and the last chapter deals with linear integral equations.

Reviewer recommends this fine work to all engineers, physicists, and mathematicians. V. Vodička, Czechoslovakia

1791. Forsythe, G. E., Alternative derivations of Fox's escalator formulae for latent roots, *Quart. J. Mech. appl. Math.* **5,** part 2, 191–195, June 1952.

Fox's essential equations for the forward and backward escalators are derived rather concisely by a more consistent use of partitioned matrixes. Fox's formulas are derived as special cases of more general relations for partitioned matrixes. This will not directly shorten the work of the practical computer, for in his work he will actually use Fox's formulas. [See also AMR 6, Rev. 696.] From author's summary by C. C. Gotlieb, Canada

1792. Flügge, S., On the numerical and graphical integration of vibration equations (in German), *Z. Phys.* **133,** 4, 449–450, Nov. 1952.

Integration of the equation $\ddot{y} + f^2(t) \cdot y = 0$ is considered for the case that the frequency $f(t)$ is a function varying slowly compared with the displacement $y(t)$. It is pointed out that the integration step can be taken much larger if, in the interval $t_n < t < t_{n+1}$, the approximation

$$y(t) = A_n \sin f_n(t - t_n) + B_n \cos f_n(t - t_n)$$

is made instead of using Taylor series. The final formulas relating y_{n+1} and y'_{n+1} to y_n and y'_n admit a simple graphical construction.

For the equation $\ddot{y} - f^2(t) \cdot y = 0$, a similar method of solution is possible by replacing the trigonometric function by hyperbolic functions, but the graphical analogy is lost.

A. I. van de Vooren, Holland

1793. Weissinger, J., Numerical integration of implicit differential equations (in German), *ZAMM* **33,** 1/2, 63–65, Jan.–Feb. 1953.

Numerical methods for solution of first-order implicit differential equations are investigated. One of author's principal objectives is the modification, simplification, and extension of the method by L. Collatz, which is as follows: To solve the implicit differential equation $F(x, y, y') = 0$ having initial conditions $y(x_0) = y_0$, $y'(x_0) = y'_0$, $F(x_0, y_0, y'_0) = 0$, transform by substituting $y' = t$ into the explicit differential equation system $dx/dt = f(x, y, t)$, $dy/dt = t \cdot f(x, y, t)$, where $f(x, y, t) = -F_t/(F_x + t \cdot F_y)$. Solution is now expressed by means of parameter t, is of the form $x(t)$, $y(t)$, and must satisfy the initial conditions $x(y'_0) = x_0$, $y(y'_0) = y_0$. The system of differential equations thus obtained may finally be solved numerically by the method of difference equations.

Other and more or less related methods for solution of implicit differential equations are now developed. Some belong to the group of successive approximation methods; some are based on difference procedures. The practical usefulness of the various methods is shown by the practical example of the differential equation

$$x \cdot y^2 \cdot y'^3 - y^3 \cdot y'^2 + x(x^2 + 1) \cdot y' - x^2 \cdot y = 0$$

with $y(1) = (3/2)^{1/2}$, $y'(1) = (2/3)^{1/2}$, and the exact solution $y = (x^2 + 1/2)^{1/2}$. M. A. Dengler, USA

1794. Richter, W., Graphical solution of ordinary differential equations by nomographic means (in German), *ZAMM* **32,** 4–5, 120–129, Apr./May 1952.

Extensive generalization of a method of H. Heinrich for graphical solution of ordinary differential equations. Heinrich draws in the xy-plane a nomogram, formed by the line at infinity z_∞ and two fields of curves $\xi_1 = \xi_1(x, y)$, $\eta_1 = \eta_1(x, y)$, and $\xi_2 = \xi_2(x, y)$, $\eta_2 = \eta_2(x, y)$, ξ_1 and ξ_2 being plotted in the x-direction and η_1 and η_2 in the y-direction. The tangent to the integral curve of the differential equation $y' = (\eta_1 - \eta_2)/(\xi_1 - \xi_2)$ in the point $P_i = P_i(x_i, y_i)$ then intersects z_∞ in the same point P_i^* as the line that connects the two points corresponding to P_i in the two fields of curves. Author generalizes by replacing z_∞ with an

arbitrary line z or by a curve or even by a variable line connecting the two corresponding points in two other fields of curves. Again, chains of nomograms can be used. At each instance, the field of application is enlarged. The curve fields may degenerate into single curves (with scales) or even points. Singularities are discussed due to coincidence of P_i and P_i^* or to indeterminateness of P_i^*. Extensions to equations of second and third orders are given. Each method is illustrated by one or two worked-out examples. A. van Wijngaarden, Holland

1795. Erugin, N. P., Construction of the whole set of systems of differential equations having a given integral curve (in Russian), *Prikl. Mat. Mekh.* **16**, 6, 659–670, Nov./Dec. 1952.

Questions of the following nature are dealt with: Under what conditions does the system

$$\dot{x} = P(x, y), \quad \dot{y} = Q(x, y) \qquad [1]$$

have $w(x, y) = 0$ as trajectory. The answer is that the system must have the form

$$\dot{x} = F_1(w, x, y) - (\partial w/\partial y)\, M(x, y)$$
$$\dot{y} = F_2(w, x, y) + (\partial w/\partial x)\, M(x, y)$$
$$F_i(0, x, y) = 0, \ M \text{ an arbitrary function}$$

If [1] is to have the trajectories $w_1(x, y) = 0$, $w_2(x, y) = 0$, then it must be of the form

$$\dot{x} = (\partial w_2/\partial y)F_1 - (\partial w_1/\partial y)F_2$$
$$\dot{y} = -(\partial w_2/\partial x)F_1 + (\partial w_1/\partial x)F_2$$

where the F_i behave as before. Various special cases are considered. The extension to a system

$$\dot{x} = P(x, y, z), \quad \dot{y} = Q(x, y, z), \quad \dot{z} = R(x, y, z)$$

with assigned trajectory $D_1(x, y, z) = 0$, $D_2(x, y, z) = 0$ is likewise taken up and it is shown that then

$$P = p(D_1, D_2, x, y, z) + [\partial(D_1, D_2)/\partial(y, z)]\, M(x, y, z)$$

with $p(0, 0, x, y, z) = 0, \ldots$. S. Lefschetz, USA

1796. Patterson, G. N., Differential equations and their characteristics, *Inst. Aerophys. Univ. Toronto, Rev.* no. 1, 28 pp., Oct. 1950.

This paper gives a useful survey of the part played by characteristic points and curves in the solution of ordinary and partial differential equations, respectively. A. R. Mitchell, Scotland

1797. Kulikov, N. K., On the determination of the limit of the general solution of a nonlinear differential equation of the first order (in Russian), *Prikl. Mat. Mekh.* **16**, 6, 729–734, Nov./Dec. 1952.

The author considers the equation

$$\dot{x} + F(x) = M \sin pt, \quad 0 < h < F'(x) = F_x < \infty$$

assumes that the general solution has a limiting solution x_∞ as $t \to \infty$, and proves that the limiting solution is given by the relation

$$F_\infty/F_{x\infty} = [M(F_{x\infty} \sin p\tau - p \cos p\tau)]/(p^2 + F^2{}_{x\infty})$$

where F_∞, $F_{x\infty}$ are F, F_x taken at x_∞. S. Lefschetz, USA

1798. Barbashin, E. A., On the stability of solution of a nonlinear equation of the third order (in Russian), *Prikl. Mat. Mekh.* 16, 5, 629–632, Sept./Oct. 1952.

Study of the stability of the solution $x = 0$ of the third-order equation

$$x + a\ddot{x} + \varphi(x) + f(x) = 0 \qquad [1]$$

where a is a positive constant, f is continuously differentiable for all x, $\varphi(y)$ is continuous for all y and $f(0) = \varphi(0) = 0$. Set

$$F(x) = {}_0\int^x f(x)dy, \ \Phi = {}_0\int^y \varphi(y)dy,$$
$$w(x, y) = \alpha F(x) + f(x)y + \Phi(y).$$

Replace also [1] by

$$\dot{x} = y, \ \dot{y} = z - ay, \ \dot{z} = -f(x) - \varphi(y) \qquad [2]$$

It is proved that the origin as a solution is asymptotically stable whatever the initial position under one of the following two sets of conditions:

I: $f(x)/x > 0$ for $x \neq 0$; $\varphi(y)/y - f'(x) > 0$ for $y \neq 0$; $w(x, y) \to +\infty$ with $x^2 + y^2$.

II: There exist two positive numbers h_1, h_2 such that $ah_2 - h_1 > 0$, and that $f(x)/x > h_1$ for $x \neq 0$; $a\varphi(y)/y - f'(x) > ah_2 - h_1$.

In the special case $f(x) = bx$, $b > 0$, the same stability result is obtained under the conditions: $\varphi(y)/y > b/a$ for $y \neq 0$; $\Phi(y) - b(y^2/2a) \to +\infty$ with $|y|$.

[References: Malkin, I. G., AMR **6**, Rev. 730; Barbashin, E. A., *Uchen. zap. Moskov. Gozud. Univ.* **II**, 1949, 110–134].

S. Lefschetz, USA

1799. Duboshin, G. N., A stability problem for constantly acting disturbances (in Russian), *Vestnik Moskov. Univ. Ser. Fiz.-Mat. Estest. Nauk* **1952,** no. 2, 35–40, 1952.

Given the system $\dot{z} = Z(t;\ z;\ \mu)$ where z, Z are k-vectors and μ is an r-vector, it is supposed that $z^* = z(t;\ z^*;\ \mu^0)$ has a solution $z^*(t;\ z^0;\ \mu^0)$. The question of the stability of this solution is discussed. By introducing new variables

$$x_i = z_i - z^*{}_i, \ i \leqslant k, \ x_{k+j} = \mu_j - \mu^0{}_j$$
$$X_i = Z_i(t;\ z;\ \mu) - Z_i(t;\ z^*;\ \mu^0), \ i \leqslant k$$
$$X_{k+j} = 0$$

the question is reduced to the discussion by standard (?) methods of the ordinary system $\dot{x} = X(t;\ x)$, where x, X have components x_i, X_i. S. Lefschetz, USA

1800. Sprague, R. E., Fundamental concepts of the digital differential analyzer method of computation, *Math. Tables Aids Comput.* **6**, 37, 41–49, Jan. 1952.

A new method of computation is described, bridging the gap between analog and digital techniques. The computer is built around a digital integrator, a set of which is driven by a pulse source representing the independent variable. The solution is presented in tabular form and a graph can be produced. Author states that the following advantages result: (1) Ease of preparing problems by using analog methods. (2) Increase in speed over digital computers and equality with some analog methods. (3) Increased accuracy over analog techniques. (4) Repeatability and ease of error analysis inherent in the digital method. (5) Small size of equipment. This new technique should help to reduce the growing complexity of computing equipment.

M. S. Weinstein, USA

1801. Speiser, A. P., Computing instruments with linear potentiometers (in German), *ZAMP* **3**, 6, 449–460, Nov. 1952.

This paper deals with electrical circuits used as computers (simulators, analog devices) and, more particularly, with the representation of arbitrary functions of one or two variables by means of such circuits. It describes a systematic method for

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determining the arrangement of components and the choice of parameters for any desired function to be computed. The circuits used consist solely of resistors and potentiometers.

The clear exposition, logical arrangement, and mathematical rigor of the paper are impressive. It is interesting that some concepts of modern mathematics, in particular the theory of lattices, enter decisively into the argument.

F. L. Alt, USA

1802. Wu, C.-H., Matrix and relaxation solutions that determine subsonic through flow in an axial flow gas turbine, *NACA TN* 2750, 65 pp., July 1952.

Author's work on turbomachines is continued in this report. Matrix and relaxation solutions are presented for incompressible and subsonic compressible flows through axial-flow gas turbines. Author states that the matrix method yielded more accurate results in a shorter time; however, convergence was obtained by both methods. First, a survey of various analyses and a discussion of previous work are given. The equations necessary for the numerical solutions are presented in a form which was obtained by the author in previous work. Then, the design conditions are prescribed (work was carried out for six sets of assigned conditions). Next, the method of solution is discussed. The principal equation to be solved is transformed into finite difference form and the calculation of the different terms presented. The method of solution of the principal equation by relaxation and matrix methods is given. The results of the incompressible and compressible solutions are discussed and compared with those of a previous approximate solution of the problem by the author.

T. P. Torda, USA

1803. Mattarolo, L., Electric analogy and method of quadripoles in heat-transfer problems (in Italian), *Termotecnica* **6,** 8, 355–363, Aug. 1952.

The well-known mathematical identity of a linear heat-flow system and an induction-free electric cable is used for expressing linear heat-flow problems in electric terminology. Numerical values of density, specific heat, thermal conductivity, "characteristic impedance," and "propagation constant" are given for 33 different materials.

Plane heat-conducting sheet is represented by electric quadripoles, with series resistance and shunt capacitance. Theory of quadripoles, connected in series or in parallel, is sketched. It is proposed to employ this theory for study of buildings in periodic temperature conditions, caused either by periodic internal heating or by a periodically varying external temperature. Different parts of building (walls, doors, windows, air spaces, etc.) are represented by quadripoles, and the whole system is reduced to a single quadripole, intercalated between an a-c voltage source and a load.

S. Ekelöf, Sweden

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1799, 1809, 1827, 1831, 1851, 1852, 1933)

1804. Arzhaníkh, I. S., Condition for applicability of the potential method of integration of equations of motion of nonholonomic conservative systems (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **87,** 1, 15–18, Nov. 1952.

Consider a holonomic conservative system and take its equations of motion in the canonical form. Substitute $p_i = p_i(t, q_1, \ldots, q_n), i = 1, 2, \ldots, n$, in the canonical potential $H(t; q_1, \ldots, q_n; p_1, \ldots, p_n)$ to obtain $\bar{H}(t; q_1, \ldots, q_n)$. Then the equations of motion are satisfied identically if one puts

$$p_i = \partial W/\partial q_i, \quad \partial W/\partial t + \bar{H} = 0$$

From this property of the Hamilton-Jacobi method, namely, of possessing a potential W for the field of impulses $p_i = p_i(t; q_1, \ldots, q_n)$, author derives the name of potential method.

Given a nonholonomic conservative system, assume for simplicity that the equations of constraints as well as the kinetic potential L do not depend explicitly on time t. Author shows that the necessary and sufficient condition for applicability of the potential method is that a certain system of partial-differential equations for W be consistent. [See also Chaplígin, AMR 6, Rev. 716, and Arzhaníkh, AMR **4,** Rev. 54.]

E. Leimanis, Canada

1805. Krasovskiĭ, N. N., Theorems on the stability of motions determined by a system of two equations (in Russian), *Prikl. Mat. Mekh.* **16,** 5, 547–554, Sept./Oct. 1952.

The stability about the point of equilibrium of the following system of equations is discussed

$$\dot{x} = f_1(x) + ay, \qquad \dot{y} = f_2(x) + by$$

where a, b are constants, and $f_1(x), f_2(x)$ are continuous functions which vanish at $x = 0$ and satisfy the conditions that guarantee a unique solution for arbitrary initial values. Author finds sufficient conditions for the motion to be stable in the form of a simple extension of Routh-Hurwitz criteria

$$f_1(x)/x + b < 0; \qquad [bf_1(x)/x - af_2(x)/x] > 0 \qquad \text{for all } x \neq 0$$

except that the following complementary condition must be satisfied

$$\lim {}_0\!\int^x [f_1(x)b - f_2(x)a]\, dx = \infty, \qquad \text{when } |x| \to \infty$$

A second theorem gives similar sufficient conditions for the system $\dot{x} = f_1(x) + ay$, $\dot{y} = bx + f_2(y)$.

Y. C. Fung, USA

1806. Duboshin, G. N., Foundation of the theory of stability of motion [Osnoví teorii ustoĭchivosti dvizheniya], Moscow, Izdat. Moskov. Univ., 1952, 318 pp.

In Lyapunov's classical memoir, "Probléme Général de la Stabilité du Mouvement" [reproduced as *Annals Math. Studies* no. 17], the theme is the stability of the origin for a system

$$\dot{x} = X(x, t) \qquad [1]$$

where $\dot{x}$ and X are n-vectors, the components X_i of X being holomorphic in x near the origin with coefficients continuous and bounded or also periodic in t. Lyapunov uses, on the one hand, direct analytical expressions for the solutions of [1]—this is his first method—and on the other hand, his second and indirect method by means of the solutions of certain partial-differential equations. Roughly speaking, the stability or instability is established by obtaining an oval surrounding the origin which contracts or expands upon following the trajectories. This second method has the advantage that, in principle at least, it does not require analyticity and dispenses with the solution of the characteristic equation. The splendid memoir of Lyapunov deals also at the beginning with his highly interesting notion of characteristic number of a real function $f(t)$ as $t \to +\infty$, a notion which does not appear to have been exploited as it should be.

The present volume is primarily a careful presentation and reworking of Lyapunov's second method, with many examples carried out in detail, and from that point of view it is most praiseworthy. However, since Lyapunov, a number of additions have been made to his theory, mostly by Soviet authors (notably Persidskiĭ and Malkin), and to these contributions the author

makes merely cursory references. Even more glaring is the total omission of any mention of Henri Poincaré, whose work had anticipated Lyapunov's in a number of places by some years. Only a bare mention is made of Lyapunov's characteristic numbers.

S. Lefschetz, USA

1807. **Liljeström, A., Theory of the top** (in Swedish), *Tekn. Tidskr.* 82, 23, 533–539, June 1952.

A tippe top is a plaything composed of a thin hollow sphere of 38-mm diam with a sixth of its diametral height truncated. In place of the portion removed, a stem 16 mm long is attached so that the stem runs normal to the truncated section. The weight of the entire plaything is 9 gm.

In equilibrium the stem is at the top. The toy is brought in rapid rotation with the fingers of the hand turning the stem, and is put on a horizontal plate. In this state, the top is unstable. Precession and nutation begin, which increase so that two characteristic states are passed through: one in which the stem is horizontal, and the other when the end of the stem first comes in contact with the plate. After these positions are achieved, the tippe top rises and spins as a top on the tip of its stem. In this final position, the sense of rotation is opposite to that of the starting movement.

The explanation of this behavior is given in the paper on the basis of the theory of the symmetrical heavy top. In the mechanism, friction between the top and the plate is essential. The problem is similar to the well-known one of the rotating egg on a horizontal plane, in which an egg rapidly rotating about an axis normal to its axis of revolution, will rise to a position of rotation about its axis of revolution. It is essential in such problems that the center of gravity has the ability to rise.

L. Föppl, Germany

Gyroscopics, Governors, Servos

1808. **Kiss, E., Contribution to the design of steam-hammer controls** (in German), *Acta Techn. Hung., Budapest* **1**, 3, 165–182, 1951.

In the recent literature, there is very little about the theory of automatic steam hammers. Therefore, it is welcome that the author deals with the calculation of the impact work, the impact number, and the steam consumption of such hammers. The importance of the degree of admission and the design of the slide valve gear are emphasized. Application of the theory is shown by an example. Agreement with practice is good.

P. Kohn, Czechoslovakia

1809. **García-Arbines y Calvo, A., Contribution to the theory of servo systems in the time domains. I, II** (in Spanish), *Rev. Cienc. apli.* nos. 26, 27; 193–212, 303–324; May/June, July/Aug. 1952.

The first part of this paper is dedicated to the detailed analysis of servo systems in terms of characteristic constants of the system. The general properties of these constants and their relation to the transient response of the system are studied and some basic relations of importance in the synthesis of servos are deduced. The second part of the paper treats methods of calculating the transfer functions of servos in order for them to give prescribed responses to given stimuli. A mathematical procedure, given by M. J. Padé in order to approximate a given function by rational fractions, is introduced into servo theory. The use of a combination of Taylor's and Padé's methods for obtaining the rational fraction expansion of the required system transfer function is studied. The use of Prony's method for accomplishing this is also considered. L. A. Pipes, USA

1810. **DeGroff, H. M., Binder, R. C., Truxal, J. G., and Burnett, J. R., Fundamental aspects of a hydraulic-type-powered flight-control system,** *Aero. Engng. Rev.* **11**, 11, 42–55, Nov. 1952.

Paper describes hydraulic control system for a typical high-speed airplane and discusses considerations in its choice and adaptation to the over-all system. Particular attention is given to possible linear approximations to the response characteristics of the actuator and to the conditions under which such approximations are valid. Direct experimental results are given to support conclusions. The root locus technique is demonstrated as an aid in the design of a stable system having satisfactory response to pilot commands. To aid in accomplishing this, a mechanical-hydraulic device, which is attached to the input of the servo control valve, is described and recommended. The action of this device is analogous to that of an electrical twin-T network. R. M. Stewart, USA

Vibrations, Balancing

(See also Revs. 1791, 1792, 1920, 2094)

1811. **van den Dungen, F. H., The Rayleigh principle and Newton's "regula falsi"** (in French), *Acad. roy. Belg., Bull. Cl. Sci.* (5) **38**, 7, 695–704, July 1952.

Author discusses two methods of finding approximate frequencies of beam vibration. Rayleigh's principle yields the same results as can be found by guessing approximate values and applying Newton's "regula falsi" to resulting error curves. Flexural vibration of a simple prismatic beam is taken as an example, using the elementary equation of motion.

R. E. D. Bishop, England

1812. **Lazan, B. J., Effect of damping constants and stress distribution on the resonance response of members,** ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-8, 9 pp.

Steady-state resonant amplification factors for several types of stressed members are calculated, assuming that the only energy losses are due to internal friction in the material. This damping is expressed as $D = JS^n$, where D is the specific damping energy, in lb/cu in./cycle, S is the stress in psi, and J and n are constants. Experimental data are given showing that J and n depend on material, temperature, and stress history. Amplification factors are determined for nonuniform direct stress and for bending of nonuniform beams of various cross sections. Amplification factor is expressed as the product of a material factor, which depends upon J, n, and the dynamic modulus of elasticity, a cross-sectional shape factor, and a longitudinal stress-distribution factor. It appears that (1) for materials having a small n (2–3), cross-sectional shape and stress distribution are relatively unimportant, and the main quantity is J; (2) for materials of high n (10–30), which includes many temperature-resistant materials, cross-sectional shape and stress distribution are very important, and small changes in shape and loading can greatly lower the amplification factor. Comparison of experimental values of amplification factor of several specimens with theory shows general agreement. Discrepancies as large as 40% for one specimen are explained by large sensitivity of result to uncertainties in n for the particular metal tested. Analysis should be valuable for a comparison of various situations and an indication of trends, even if a lack of complete information should make it difficult to compute accurate values for specific cases. D. E. Hudson, USA

1813. **Kanai, K., and Yoshizawa, S., On the damping of vibration of actual buildings. I,** *Bull. Earthq. Res. Inst., Tokyo Univ.* **30**, part 2, 121–126, June 1952.

Authors give results of forced-vibration tests on buildings of

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one to seven stories and of ferro-concrete, concrete block, and wooden construction. Damping coefficient and natural period were measured for beam and girder directions. Dissipation of energy into ground is taken as dominant source of damping.
R. D. Specht, USA

1814. Ehrmann, H., On the connection between the amplitude and period in free undamped vibrations (in German), *ZAMM* **32,** 10, 307–309, Oct. 1952.

For the equation, $\ddot{x} + f(x) = 0$, paper develops method for determining $f(x)$, not of form cx, which yields period of vibration independent of amplitude. R. P. Felgar, Jr., USA

1815. Lubkin, J. L., and Luke, Y. L., Frequencies of longitudinal vibration for a slender rod of variable section, ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-27, 5 pp.

Natural frequencies of longitudinal vibrations of slender homogeneous fixed-free rod, uniform for $0 \leq x \leq L_1$ and linearly tapering for $L_1 \leq x \leq L_2$ (= end point), are calculated in accordance with one-dimensional equation $\rho A(x)u_{tt} = E[A(x)u_x]_x$; A is cross-sectional area, E Young's modulus. First five zeros of resulting frequency equation

$$0 = \sin\gamma\,\{J_1[\beta(1+\epsilon)]Y_1(\beta) - Y_1[\beta(1+\epsilon)]J_1(\beta)\} + (\epsilon/|\epsilon|)\cos\gamma\,\{J_1[\beta(1+\epsilon)]Y_0(\beta) - Y_1[\beta(1+\epsilon)]J_0(\beta);$$

$$\beta = \nu_n L_2/|\epsilon|;\quad \gamma = \nu_n L_1;$$

J, Y first and second kind Bessel functions, have been determined, to 1 unit in fifth sign digit of ν_n, for $L_1/L_2/1 + L_1/L_2 = 0(.125)1.0$ and $[A(L_2) - A(0)]L_2/(L_2 - L_1) = -1(1/3) + 1$. Interpolation with at least 1% accuracy is possible. Discussion of asymptotic expansions for roots of frequency equation is presented. J. H. Greidanus, Holland

1816. Sekhniashvili, É. A., On the determination of the natural modes of vibration of systems with an infinitely large number of degrees of freedom (in Russian), *Soobshch. Akad. Nauk Gruz. SSR* **12,** 149–154, 1951.

Author remarks that a practical method of finding an arbitrary mode of vibration for a system with infinitely many degrees of freedom does not exist up to now, and he claims to fill this gap for an elastic bar of arbitrary form. By Galerkin's method, the problem is reduced to the solution of a system of infinitely many linear homogeneous equations with infinitely many unknowns. The natural frequencies are found by equating the determinant of this system to zero. The remark that at the zeros of this determinant its rank is one is not clear to reviewer. Finally, the author explains the well-known fact that the vibration of the bar for given initial deflection and velocities can be expressed by the characteristic solutions. W. H. Muller, Holland

1817. Rasmussen, B. H., Earthquake forces on systems with several degrees of freedom, *Bull. seism. Soc. Amer.* **42,** 4, 327–339, Oct. 1952.

Paper begins with general description of free and forced vibration of system of n-degrees of freedom by use of matrixes. Equation is solved when external force acts impulsively, and some discussions consider the effect of length of duration time of force. Assuming that strong-motion earthquake is composed of a set of random shocks, author introduces practical expression for maximum equivalent acceleration of each degree of freedom. Further consideration is given to a sample n-story rigid-jointed frame with very rigid beams, and maximum shears in ground and top floor are evaluated.

Damping forces are considered to be absent, but the circumstances bring no essential changes into results in the present case. Assumption of earthquake forces to be composed of impulsive forces, however, should be included when a more practical treatment of the problem is undertaken. K. Kasahara, Japan

1818. Wenk, E., Jr., Radial impact on an elastically supported ring, *Proc. Amer. Soc. civ. Engrs.* **78,** separ. no. 157, 25 pp., Nov. 1952.

Author extends simple theory of small inextensional undamped vibration of thin circular elastic ring to problem of forced motion with radial and tangential elastic support. Free vibration is examined by conventional methods. Solutions are found for motion produced by concentrated radial sinusoidal force and a half-wave pulse of this type.

Experimental confirmation is sought, using 24-in. diam × 0.125-in. (radial) × 1-in. steel hoop, supported radially by equally spaced springs and carrying strain gages. Natural frequencies are checked by steady forcing, giving good agreement up to 7th flexural mode. Transient problem is examined by longitudinal impact of a bar, bending strains and radial deflections being recorded. Reasonable agreement is found between experiment and analysis, both during period of impact and in subsequent era of free motion. R. E. D. Bishop, England

1819. Giovannozzi, R., On the static and dynamic behavior of an elastic joint with nonlinear characteristic (in Italian), *Monogr. Lab. Aero. Politecn. Torino* no. 283 = *Atti Accad. Sci. Torino* **86,** 16 pp., 1951–1952.

Bibby couplings have nonlinear relation between twist and torque due to change of position of contact points of force transmitting laminae with load. This relation and the laminae are given in dimensionless form. Period of free oscillations with given finite amplitude is calculated and tabulated for different equilibrium positions. F. K. G. Odqvist, Sweden

1820. Moiseev, N. N., On the oscillations of a heavy ideal incompressible fluid in a vessel (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **85,** 5, 963–965, Aug. 1952.

Free vibrations of an ideal incompressible fluid which is confined to a container having a free surface are analyzed. Author evaluates: (a) Natural frequencies of the free vibrations of the fluid; (b) the shape of the free surface; (c) kinetic and potential energies of the vibrations. M. Strscheletzky, Germany

Wave Motion, Impact

(See also Revs. 1813, 1835, 1836, 1963, 1965, 1966, 1971, 1999, 2065, 2091, 2095, 2096)

1821. Biesel, F., Study of wave propagation in water of gradually varying depth, "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 243–253, Nov. 1952. $1.75.

First-order and second-order approximate theories are presented. Squares of bottom slopes, bottom curvature, and derivatives higher than h_x are neglected. Numerical solutions for breaking of waves on a beach of constant slope are given. However, the reviewer believes that the results are not reliable for small depths as the neglected terms become increasingly important when the depth decreases. Y. V. G. Acharya, Holland

1822. Eckart, C., The propagation of gravity waves from deep to shallow water, "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 165–173, Nov. 1952. $1.75.

An approximate wave equation is derived for surface elevation

of gravity waves on water of any depth from linearized Eulerian equations and boundary conditions. Author clearly indicates approximations applied and points where mathematical justification is needed. In the case of constant depth, solution of derived equation satisfactorily approximates (within 5%) classical first-order solution [cf. Lamb, "Hydrodynamics," ch. VIII, IX].

For bottom of constant slope, a solution is obtained in terms of hypergeometric function; with adequately chosen independent variable, wave equation appears to be separable. For small slope and shallow water, solution is shown to converge to solution of Stoker [AMR **1**, Rev. 179]. Applicability of formula for steep slopes is not investigated.

Only mathematical results are given; applications are to be reported elsewhere. H. J. Schoemaker, Holland

1823. **Dressler, R. F., Stability of uniform flow and roll-wave formation,** "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 237–241, Nov. 1952. $1.75.

Author discusses the stability of initially uniform open-channel flow down an inclined chute and finds criteria for the formation of "roll-waves," a periodic motion with a progressing-wave profile which moves downstream faster than the fluid particles. For a resistance formula $-r^2u^n/y^m$, the roots of the disturbance equations, obtained from the two-dimensional shallow-water wave equations by assuming small perturbations in velocity and depth, are examined. Here, r^2 is a constant, u is velocity, and y is depth. For the Chezy formula, $n = 2$, $m = 1$, the criterion for instability is $\tan\theta > 4r^2$, θ being the inclination of the channel, confirming previous results obtained by Jeffreys [*Phil. Mag.* **49**, 1925] and, by other methods, by the author [AMR **3**, Rev. 1724]. Instability cannot occur if resistance is independent of either velocity or depth. The flow is subcritical at the crests and supercritical in the troughs. P. Eisenberg, USA

1824. **May, A., Vertical entry of missiles into water,** *J. appl. Phys.* **23**, 12, 1362–1372, Dec. 1952.

Investigations, carried out principally on the vertical water entry of steel spheres, are described. Graphs show the effect of several experimental parameters on the time and place of occurrence of various events in the life of the cavity which accompanies the entry. These parameters include the density and pressure of the atmosphere above the water, and the velocity, size, and nose shape of the missile. Froude scaling is found to be a good first approximation in describing cavity behavior, and some improvement is effected by the pressure-density scaling of the atmosphere above the water. The energy lost by a missile during the open-cavity phase of its water entry is found to be used up principally in the formation of the cavity, and the cavity shape is not dependent on the nose shape of the missile for a given drag force. From author's summary by R. F. Smiley, USA

1825. **Rinehart, J. S., Scabbing of metals under explosive attack: multiple scabbing,** *J. appl. Phys.* **23**, 11, 1229–1233, Nov. 1952.

Scabbing of metals under explosive attack is the tensile failure of the material on the side opposite to the compressive impact. An earlier paper [AMR **4**, Rev. 4166] discussed the mechanism of scabbing, and the present paper indicates how multiple scabbing can occur if the initial compressive wave is sufficiently intense. It is shown that the number of scabs that will form is equal to the first whole number smaller than σ_0/σ_c, where σ_0 is the maximum compressive stress striking the free surface, and σ_c is the critical normal fracture stress (tensile) of the material. The effect of a backing plate at the free surface is also discussed. Experimental verification of the reasoning is presented.

E. E. Sechler, USA

1826. **Campbell, W. R., Determination of dynamic stress-strain curves from strain waves in long bars,** *Proc. Soc. exp. Stress Anal.* **10**, 1, 113–124, 1952.

A tensile impact is given to the end of a rod producing plastic waves. Resistance strain gages at two sections record the strain variation with time, so that the propagation velocity for each strain amplitude is determined. Rod is sufficiently long to avoid reflections. Theory of plastic waves [von Kármán and Duwez, AMR **4**, Rev. 2481] then permits the calculation of the corresponding dynamic stress-strain relation. Preliminary experimental results are given for hard and soft copper. Initial results seem promising, and improvements for future work are suggested.

E. H. Lee, USA

1827. **Schnitzer, E., Theory and procedure for determining loads and motions in chine-immersed hydrodynamic impacts of prismatic bodies,** *NACA TN* 2813, 51 pp., Nov. 1952.

A theoretical method is derived for the determination of the motions and hydrodynamic loads during the water impact of prismatic bodies whose chines may penetrate substantially below the water surface. The theory is particularly applicable to seaplane hulls with large beam loadings and to seaplanes with hydro-skis. The derivation is based on the concept that, for bodies of low aerodynamic aspect ratio like seaplane hulls, the fluid flow about the seaplane can be considered to be essentially two-dimensional in transverse planes perpendicular to the longitudinal axis of the seaplane. Using this concept together with the concept of the water mass associated with the downwash momentum, differential equations are derived and solved for the motions and forces on the seaplane for the two cases of constant velocity parallel to the keel (pertinent to actual seaplane landing conditions) and for constant horizontal velocity (pertinent to experimental tank tests). Graphs of various functions needed for the use of the equations are presented to facilitate computations. Comparisons of theoretical and experimental time histories and maximum values of draft, velocity, and hydrodynamic load are presented, covering the two cases of a rectangular flat plate and a 30° dead-rise angle prism for trims up to 45°, flight-path angles up to 90°, and for beam-loading coefficients from 1 to 36.5. Fair agreement is found over these ranges. R. F. Smiley, USA

1828. **Craggs, J. W., The normal penetration of a thin elastic-plastic plate by a right circular cone,** *Proc. roy. Soc. Edinburgh* (*A*) **63**, part 4, no. 26, 359–370, 1952.

A study is made of the propagation of elastic and plastic deformation in a thin plate, initially unstressed and of infinite extent, when it is penetrated normally by a cone moving with uniform velocity. The work is an extension of unpublished researches by Sir G. I. Taylor on the corresponding problem for a thin wire, and a summary of his results is included.

From author's summary by V. P. Zimnoch, USA

1829. **Williams, E. A., and Isaacs, J. D., The refraction of groups and of the waves which they generate in shallow water,** *Trans. Amer. geophys. Un.* **33**, 4, 523–530, Aug. 1952.

Calculations of group refraction based on Stoneley's theory [*Proc. Camb. phil. Soc.* **31**, 360–367, 1935] are carried out for 14-sec phase waves approaching (a) a beach of constant slope (= 0.0425) at an initial angle of 30°, and (b) the irregular ocean bottom north of La Jolla, Calif., from WNW. The breaking-wave group is assumed to generate a long period wave (surf beat) whose seaward path is determined from Huygens's principle, assuming the one-fathom line to be the line of wave generation. Analytical formulas for the surf-beat path on a beach of constant slope are based on Fermat's principle of minimum time. Re-

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viewer notes that the surf-beat paths in this case are cycloids, the formulation being that of the classical brachistrochrone problem. R. A. Fuchs, USA

1830. Kharkevich, A. A., Transient wave phenomena [Neustanovivshiyesya vol novyie yavleniya], Moscow-Leningrad, Gosud. Izdat. Tekh.-Teor. Lit., 1950, 202 pp.

Monograph is divided into two main parts. The first explains the usual theory of wave motion and can be regarded as a short mathematical and physical introduction to the second main part which deals with unsteady processes. Reader's attention is called especially to original methods for solving problems on diffraction of waves.

The book must be recommended to all engineers interested in acoustics and in the field of mechanical and electric waves; it will improve their theoretical education in this subject.

V. Vodička, Czechoslovakia

Elasticity Theory

(See also Revs. 1843, 1847, 1854, 1856, 1858, 1859, 1864, 1866, 1876, 1880, 1887, 1894, 1901, 1917)

1831. Den Hartog, J. P., Advanced strength of materials, New York, McGraw-Hill Book Co., Inc., 1952, ix + 379 pp. $8.50.

This book is a welcome addition for engineers, both as a reference book and as a classroom text. The subject matter is chosen to give a well-rounded study of strength of materials on an advanced level, and book serves as an excellent sequence to author's book on mechanics (same publisher, 1948). Much of the material is presented from the engineer's point of view in that approximations are made when needed, with no compunctions about loss of formalization. Yet the coverage of the mathematics is sufficient to dispel any fears of oversimplification.

The text is divided into nine chapters: Torsion (pp. 1–48); Rotating disks (pp. 49–69); Membrane stresses in shells (pp. 70–99); Bending of flat plates (pp. 100–140); Beams on elastic foundations (pp. 141–170); Two-dimensional theory of elasticity (pp. 171–211); The energy method (pp. 212–250); Buckling (pp. 251–307); and Miscellaneous topics (pp. 308–325). Pertinent problems are suggested at the end of each chapter. These problems with their answers are collected for convenience at the end of the book. In addition, illustrative examples are worked in the text to facilitate understanding of the principles or methods being discussed. The last chapter on miscellaneous topics covers Mohr's circle, torsion of pretwisted thin-walled sections, and the theorems of Biezeno and Spielvogel. The chapters on torsion and two-dimensional theory of elasticity treat, in part, the membrane analogy and the Airy stress function.

A desire on the part of the author to bring about an easy transition from basic theory to practical solutions is shown by the geometric interpretation and physical meaning that are attached to the problems. The book is characterized by an easy style, yet the material is presented clearly and concisely. The author has made a step toward "taking the strait jacket off technical style" and has, thereby, added greatly to the value of the book.

E. D'Appolonia, USA

1832. Timpe, A., Bridge solution in the problem of axisymmetrical torsion (in German), *ZAMM* **32,** 7, 226–227, July 1952.

On the basis of biharmonic solutions given in polar spherical coordinates, author supplements previous solutions of axially symmetric torsion problems [AMR **4,** Rev. 583] with seven additional types. Two illustrative examples are appended showing how new solutions of these axially symmetric cases are obtained by spherical inversion. D. L. Holl, USA

1833. Milne-Thomson, L. M., Finite deformations and elasticity (in Spanish), *Rev. Mat. Hisp.-Amer.* (4) **12,** 9–35, 1952.

Essentially an expansion of the author's earlier paper [AMR **3,** Rev. 2215], which, in turn, was essentially a translation into dyadic notation of Murnaghan's presentation [*Amer. J. Math.* **59,** 235—260, 1937] of the classical theory of finite elastic strain.

C. Truesdell, USA

1834. Smith, J. O., and Liu, C. K., Stresses due to tangential and normal loads on an elastic solid with application to some tact stress problems, ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-13, 10 pp.

The stress components for two-dimensional Hertzian stresses are given for normal and tangential loading, without proof; these agree with those obtained by Poritsky [*J. appl. Mech.* **17,** 191–201, 1950]. On the basis of these, curves of the normal and shear stresses in the x, z directions are shown for various x, z, and contours of the principal stresses are given for a friction coefficient of 1/3. It is shown that for this combination the maximum principal stresses and the maximum shear stress are at the surface. The effect of range of stress on fatigue is discussed with particular reference to the wheel-rail combination.

Reviewer notes with regret the absence from the bibliography of his own paper [AMR **3,** Rev. 1054] in which stress components for same problem with friction were given earlier than in cited literature. E. M'Ewen, England

1835. Satô, Y., Velocity of elastic waves propagated in media with small holes, *Bull. Earthq. Res. Inst., Tokyo* **30,** 3, 179–190, Sept. 1952.

In order to account for porosity of material, the elastic constants and the velocity of elastic waves are expressed in terms of relative density $\rho = \delta:\delta_0$, where the density of the real material is δ_0, and δ that of an actual material. To compute the velocities of P- and S-waves, author makes use of expressions for elastic constants in case of empty holes obtained by J. K. Mackenzie [AMR **4,** Rev. 587], and extends the results to the case of spherical holes filled with liquid. W. S. Jardetzky, USA

1836. Pierushka, R., Fundamental equations for elastic, an isotropic media (in German), *Ing.-Arch.* **20,** 4, 229–233, 1952.

Stress-strain equations are derived for the small deformations of a homogeneous material with three mutually perpendicular axes of elastic symmetry. The wave equations for dilatational disturbances alone and for shear disturbances alone are obtained, and some simple solutions of these equations are found.

H. G. Hopkins, USA

1837. Huth, J. H., Thermal stresses in a partially clamped elastic half-plane, *J. appl. Phys.* **23,** 11, 1234–1237, Nov. 1952.

A semi-infinite solid is subjected to a uniform change of temperature; the lateral thermal expansion of a strip of constant width on the plane boundary of the solid is prevented by attaching a perfectly rigid plate to it. (The plate is permitted to move freely at right angles to the plane boundary.) The complex stress functions corresponding to the resulting plane strain condition are established essentially by Muskhelisvili's method; formulas and graphs are given for the stresses (normal and shear) between the semi-infinite solid and the attached plate, the displacements of the free boundary, and the stresses in the solid along its vertical axis of symmetry.

The notation used (width of plate = 2) makes the formulas presented dimensionally inconsistent.

G. Sved, Australia

1838. **Legendre, R., Doubly complex biharmonic functions and applications to elastostatic problems** (in French), *Publ. sci. tech. Min. Air, Paris, NT* 42, 45 pp., 1951.

A version of L. Sobrero's theory of hypercomplex functions [see AMR **4**, Rev. 1476; **5**, Rev. 1971] is developed and applied to two-dimensional stress analysis. Given are three illustrative examples—an infinite plate with an elliptic hole, that with a hypotrochoidal hole, and a semi-infinite plate under elliptically distributed edge tension—the results coinciding with known solutions. No reference to previous work is given. The same method seems to have been used by author in another paper [AMR **5**, Rev. 3037]. Reviewer remarks that although this device gives an elegant way of expressing fundamental relations, it would, in actually solving concrete problems, amount to the same thing as the well-known method using two analytic functions.

S. Moriguti, Japan

Experimental Stress Analysis

(See also Revs. 1899, 2024)

1839. **Boiten, R. G., and Ten Cate, W., A routine method for the measurement of residual stresses in plates,** *Appl. sci. Res. (A)* **3**, 5, 317–343, 1952.

Paper comprises report on first part of research program to develop a satisfactory testing technique for applying so-called drill-hole method of determining residual stress in plates. Plate is assumed subject to biaxial normal stress combined with pure bending about two perpendicular axes. Formulas are developed for calculating stresses from gage output (using six wire-resistance gages, three mounted on each side of plate). Effects of averaging strains over gage length and of transverse sensitivity are considered. Description of testing technique is given. Experimental results are presented for cases involving tension and bending. Authors believe that, in practice, method may be applied with an error under 10%. It is suggested that further work is necessary along various lines; e.g., testing technique, high stress levels, three-dimensional states of stress.

A. M. Wahl, USA

1840. **Bühler, H., A complete determination of the state of internal stress in metallic full and hollow cylinders** (in German), *Z. Metallk.* **43**, 11, 388–395, Nov. 1952.

Residual stress measurements by Sachs' boring-out method rely on extrapolation for deformation relaxation in outside layer. Subdivision by turning from outside has become possible with the advent of the electric resistance strain gage which can be attached inside bore and for which author gives useful hints on the technique of attachment. Equations for stress determination from measured deformations inside bore are deduced. Assuming state of stress in tube independent of length coordinate, cylinder can be halved, one half being used for boring out, one half for turning off, thus avoiding extrapolation. Experimental results are given for brass tube 60-mm OD, 25-mm ID, 250 mm long, and steel tube 100-mm OD, 50-mm ID, 500 mm long in which residual stresses introduced by quenching show coincidence of separate curves obtained by boring and turning over central range. Since ends of tube must be stress-free, halving must change state of stress. Author shows that effect is negligible if gages of 20-mm length are used and length of tube is equal or greater than twice the diameter. Throughout the investigation, rotary symmetrical state of stress independent of length coordinate is assumed a priori, as in Sachs' boring-out method, and measurements are confined to cross section equidistant from both ends. Reviewer thinks these unverifiable assumptions are open to doubt for quenched cylinders.

R. Weck, England

1841. **Schwaigerer, S., Experimental determination of stresses in structural members** (in German), *ZVDI* **94**, 32, 1025–1036, Nov. 1952.

Author surveys the established methods of experimental stress analysis and describes various types of strain-measuring devices. Some of these devices, which are no doubt quite familar to European stress analysts, seldom are seen or heard of in America. This category includes the Johanssen extensometer, Ritz strain meter, pneumatic strain gage, various types of mirror extensometers, a photoelectric strain gage, and stretched-wire extensometers. All of these are illustrated and discussed by the author. On the other hand, such common devices in America as the Berry strain gage are not included in the survey.

Author also discusses x-ray strain measurements, photoelasticity, the membrane and hydrodynamic analogies for shear stress determinations, and brittle lacquer as a strain-measuring device. Discussions of these various techniques are necessarily very brief, but are sufficient to give a reasonably clear picture of the fundamental theory in each case.

A short discussion of the evaluation of strain measurements, and of methods for determining strain in regions of rapid change when extensometers of finite gage length only are available, is included.

E. A. Ripperger, USA

1842. **Jessop, H. T., Scope and limitations of photoelastic stress analysis,** *Engineering* **174**, 4535, 833–834, Dec. 26, 1952.

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 1818, 1826, 1831, 1870, 1896, 2106)

1843. **Gill, S. S., The behaviour of beams in bending,** *Aircr. Engng.* **24**, 285, 336–343, Nov. 1952.

Paper reports experiments carried out on beams in pure bending. The material used was a cast magnesium alloy AZ855. The beam sections were rectangular, circular, I-section, T-section, and diamond. One series of tests was carried out up to $1^1/_2\%$ fiber strain. A second series of tests was carried out up to fracture. Tension and compression tests were also made on the material.

The experimental results show conclusively that the usual theory of plastic bending is correct and that the tension-compression stress-strain curve of the material may be used to determine the bending moment-curvature relationships, etc., for a beam. Measurements of neutral axis shift also confirm the predictions of plastic-bending theory.

From author's summary

1844. **Ratzersdorfer, J., Solutions of problems on the slightly curved beam,** *Aircr. Engng.* **24**, 284, 288–293, 319, Oct. 1952.

A slender beam with slight geometrical curvature is divided in bays with different cross sections subjected to uniformly distributed and concentrated transverse loads. Combined with the conditions which hold at the first and last point of the beam, the bending moments at the ends of the bays will be determined by three moment equations, or, when uniformly distributed transverse loads are operative, graphically by use of polar coordinates. Knowing these moments, a polar diagram can be completed for each bay. Further, a convenient method is shown for the solution of deflections of the beam. An additional remark deals also

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with the beam under tension. Finally, numerical examples give an illustration of the procedure.

From author's summary by C. B. Matthews, USA

1845. Szelagowski, F., Computation of a beam system reinforced by an arch (in Polish), *Inżyn. Budown.* **9,** 6, 199–201, June 1952.

Paper presents a contribution to bridge designing. Current way of calculating a beam reinforced by an arch is based upon assumption that reinforcing arch consists of pin-jointed bars. These are attached by vertical bars, also pin-jointed, to horizontal beam. Author considers system consisting of both free supported elastic straight beam and arch connected by means of vertical pin-jointed bars. He calculates separately the bending moments for these two fundamental elements and, by adding them, obtains bending moment of the system. Thus the law of superposition holds; system is linear and no interference between fundamental elements is considered. Applying elementary formulas, assuming parabolic arch, author calculates horizontal, shearing, and normal forces, and plots influence lines for them. Influence of temperature variation results in additional equations. Mathematics used is simple, presentation is clear.

M. Z. Krzywoblocki, USA

1846. Shibuya, I., On the stress concentration of a shaft with various shaped grooves twisted by couples. Part I, II, III, *Rep. Inst. high Speed Mech., Tôhoku Univ.* **1,** 47–68, 1951.

Choosing the origin at the center of the groove, author replaces the equation of torsion stress function by a group of successive equations formed according to the powers a/r_0, where a, the magnitude of the groove, is small compared with r_0, the outer radius of the shaft. The solution of the equation of first approximation is a harmonic function. These equations are solved successively, and the arbitrary constants involved in the solution are determined to satisfy boundary conditions. Such solution, however, cannot be applied to part of shaft far from the groove. In parts I and II, the above method is applied to find stress-concentration factor of shaft with a semicircular, a right-angle V, and a periodically distributed notched groove. In part III, complex potential function in the form $UZ + F(z)$ where $z = x + iy$, and U, a constant, are employed for complex stress function. Using the above successive equations of approximation and adapting $F(z)$, the case for shallow circular groove is discussed. Diagrams for stress-concentration factors are presented which may be useful for design of machine parts. D. N. Mitra, India

1847. Reissner, E., On non-uniform torsion of cylindrical rods, *J. Math. Phys.* **31,** 3, 214–221, Oct. 1952.

Author shows how his variational theorem for stresses and displacements [AMR **4,** Rev. 2381] may be used for the approximate determination of corrections to the Saint Venant theory of torsion of cylindrical rods, induced by restraint against warping at the end section.

For applying the variational equation, the following assumptions are made: For the stresses $\sigma_x = \sigma_y = \tau_{xy} = 0$ (x, y are the coordinates in the cross section, z is the axis of the rod), for the displacements $u = \beta(z)y$, $v = -\beta(z)x$, with the boundary conditions $\beta(0) = 0$, $w(x, y, 0) = 0$. Using three different additional approximations for displacements or stresses, namely, I: $w\beta'(z)\phi(x, y)$, II: $w = \alpha(z)\phi(x, y)$, III: $\sigma_z = \sigma(z)\phi(x, y)$, one gets in every case a differential equation for $\beta(z)$ when $\phi(x, y)$ is especially the warping function of Saint Venant's theory. Assumption I leads to a result given by H. Wagner [25th Ann. Publication, Techn. Hochschule, Danzig, 1929] and also by J. N. Goodier [*Cornell Engng. Exp. Sta. Bull.* no. 27, 1941]. Numerical results for special cross sections are not given.

H. Kauderer, Germany

1848. Morice, P. B., On centers of twist in nonhomogeneous beams, *Mag. Concr. Res.* no. 11, 63–66, Oct. 1952.

Beams considered are of rectangular section reinforced so that the cross section has a single axis of symmetry. Since the center of twist is indeterminate in the Saint Venant (linear) torsion, author takes into account strains induced in longitudinal fibers ("shortening effect") at finite twists. Results are obtained from condition of minimum strain energy. Variation of position of center of twist with percentage reinforcement is shown graphically for a particular placement of reinforcement.

Reviewer notes that the shortening effect can account for only negligible fraction (less than 1%) of applied torque in practical circumstances. Accordingly, its effect upon stresses in actual structures of this type may be expected to be imperceptible.

R. E. Newton, USA

1849. Kisiel, I., On rational dimensioning of foundations for power hammers (in Polish), *Inżyn. Budown.* **9,** 9, 288–292, Sept. 1952.

Article presents contribution to dimensioning of foundations for power hammers; calculation of foundations for such hammers as consisting of two independent vibrating systems is incorrect. It is much better to calculate them as a system consisting of two masses (anvil and foundations) and two springs (blocks of wood or felt between anvil and foundations and ground or springs under foundation). Under these assumptions and assumption of imperfectly elastic shock, author calculates vibrations of the system by means of exact and simplified equations and dimensions of foundations in a particular numerical example. He discusses critically both (anvil on foundations and foundations on ground) dynamic coefficients of pressure and concludes that they should be smaller. Proposition leads to rational dimensioning of foundations and saving of material. Mathematics involved is elementary.

M. Z. Krzywoblocki, USA

1850. Vörös, I., Some problems of gear design and manufacture, *Acta Techn. Hung. Budapest* **4,** 1/4, 365–397, 1952.

Paper was a lecture on the design and fabrication of spur gears. In considering the strength of gear teeth, the following items are discussed in detail: Bending strength or Lewis load, stress concentration, dynamic load, endurance limit, and wear resistance. Some practical methods for improving the performance of gears are advanced, such as the correction for equalizing the slip between mating teeth, the tip relief for modifying the fluctuation of angular velocity, the production processes for manufacturing gears of high accuracy, and the grinding methods for producing highly polished tooth surfaces.

However, the Hungarian practice of gear-making, as discussed in this paper, is very similar to methods adopted by the United States. L.-W. Hu, USA

1851. Baumgartner, A., Calculations for gears with increased pinion diameter to avoid undercut (in German), *Schweiz. Bauztg.* **70,** 44, 45; 623–629, 639–645, 649; Nov. 1952.

Permissible corrections for tooth addendum, etc., in gears with a basic rack of the metric 20° full-depth involute system are dealt with. There are tables for the center distance extension of spur gears, the pressure angle of helical gears, and for the base circular pitch and modulus. This last table contains numerous errors. Paper also contains examples for calculation of correction factors. Numerical results are unnecessarily complicated by the use of too many decimals. A. R. Holm, Denmark

1852. **Boerdijk, A. H., A new aspect in the calculation of toothed gearing,** *Ingenieur* **64,** 37, W.63–W.65, Sept. 1952.

Author discusses calculation of the numbers of teeth of the wheels in a gearing with a prescribed gear ratio, equal to the quotient of two integers k/l. The known methods of decomposing k and l into prime factors and of developing k/l in continued fractions often fail to give a practical and exact solution. A new method is described, based on the introduction of planet gearings (or simple differentials) in the conventional gearing. Practical and exact solutions can be obtained for arbitrary values of k and l, even for very large primes.

From author's summary

1853. **Saito, H., The axially symmetrical deformation of a short circular cylinder** (in Japanese), *Trans. Soc. mech. Engrs. Japan* **18,** 68, 21–28, Mar. 1952.

A method is described for solving the problem of stress and displacement in a short circular cylinder or a thick circular disk deformed symmetrically with respect to the axis. Using a stress function in the form of Fourier-Bessel series and separating the surface traction into eight cases, each of which is expanded in a series of trigonometric or Bessel functions, the stress system for each case is found and the general solution is obtained combining these stress systems. The method is applied to a short circular cylinder, strained by surface tractions, viz., (1) uniform pressure distributed over the middle zone of the cylindrical surface, and (2) uniform pressure distributed over a central circular area of the end surface of the cylinder. T. Udoguchi, Japan

1854. **Frandsen, P. M., On the solution of Clapeyron's equations** (in Danish), *Bygnstat. Medd.* **23,** 3, 24 pp., 1952. Kr. 6.

In conjunction with author's preceding solution of Clapeyron's elastic equations as second-order equations of differences [*Eisenbau* 1913, pp. 440–451], this paper gives a corresponding solution of systems of triple-term equations, characterized by having entirely arbitrary coefficients for which Maxwell's theorem does not apply. The solutions are obtained as ordinates to a funicular polygon for certain forces acting upon an indirectly loaded beam contingent on the equation coefficients. For Clapeyron's elastic equations the determination of influence lines for the redundants is shown as curves of deflections produced by series loadings, substituted for the redundants with one series for each influence line. The series may be determined summarily or individually. Numerical examples are given.

From author's summary by S. E. Kindem, Norway

Plates, Disks, Shells, Membranes

(See also Revs. 1831, 1869, 1878)

1855. **Caldwell, J. B., Bending strength of corrugated plate,** *Engineering* **174,** 4528, 609–612, Nov. 1952.

Paper shows the calculation of the ultimate bending strength of typical forms of corrugated plate. A semiempirical method for calculating the instability of the web is given. In this method, the web is replaced by a uniformly compressed plate with a different width, giving a critical buckling compressive stress equal to the extreme fiber stress of the web at buckling, obtained from tests of the corrugated plate under pure bending. The selection of trough forms is discussed. T. H. Lin, USA

1856. **Doucet, E., Remarks on the solution of the problem of thin rectangular plates given by Navier** (in French), *Génie civ.* 129, 21, 409–411, Nov. 1952.

Author investigates Navier's solution for bending of a thin rectangular plane plate, and remarks that Fourier's double series obtained for some simple condition of the charge is not absolutely convergent. Reviewer believes that absolute convergence is not necessary for a double series, being the convergence often considered as proposed by Stolz and Pringsheim. For general theorems on the convergence of Fourier's double series, see, e.g., Tonelli's book "Serie trigonometriche," Bologna, 1928, chap. IX.

G. Supino, Italy

1857. **Woinowsky-Krieger, S., The bending of a wedge-shaped plate,** *J. appl. Mech.* **20,** 1, 77–81, Mar. 1953.

A solution is given for the bending of a wedge-shaped thin elastic plate of infinite radius under a concentrated load. Each of the two radial edges may be simply supported, clamped, or free. The solution consists of two expressions in the form of Fourier integrals, one for each side of the radial line on which the load is applied. The solution is carried out in detail for a plate with clamped edges and a simple load on the bisector radius. Curves are shown giving moments and shears along the clamped edges for different wedge angles for this case.

Reviewer notes that the line between Eqs. (34) and (35) should be corrected to read: "If, in particular, $\psi(r) = 0$ for $r \neq r_0$ and ${}_b\int^a \psi(r)\, dr = r_0 2P$, then. . ." G. Pickett, USA

1858. **Kalandiya, A. I., General mixed problem of bending of an elastic plate** (in Russian), *Prikl. Mat. Mekh.* **16,** 5, 513–532, Sept./Oct. 1952.

Paper presents application of singular integral equations for determining elastic deformations of a plate with boundaries partly restrained, partly freely supported, and having some edges unsupported. Mixed problem of determining deflections is demonstrated by an example where one part of the periphery of the elastic plate is restrained (fixed) and the other parts free. In this case, Fredholm's equations are used and further references are given. J. J. Polivka, USA

1859. **Kuhelj, A., Contribution to the theory of elasticity of shells** (in German), Inter. Assn. Bridge struct. Engng., Fourth Congr., Cambridge and London, 199–212, Aug./Sept. 1952.

A development of fundamental equations of theory of elastic shells employs assumptions that normals to middle surface remain normal, and that quadratic terms in strain tensor are negligible. Clarity and conciseness are enhanced by application of theorems of classical differential geometry, and by use of vector analysis. Formulas equivalent to those derived in paper have appeared previously in the writings of Love, Flügge, E. Reissner, Parkus, and others. H. L. Langhaar, USA

1860. **Karunes, B., On the distribution of initial stress due to dislocation in an infinite plate containing two unequal circular holes,** *Indian J. Phys.* **26,** 7, 317–328, July 1952.

Bipolar coordinates are employed to obtain initial stresses in an infinite plate containing two circular holes when a cut parallel to a common diameter and joining the two holes is cemented together. Three Airy stress functions $\chi = \chi_0 + \chi_1 + \chi_2$ are employed, the first causing a constant dislocation of displacements along the cut but inducing normal stresses over the circular boundaries. The second annuls these stresses but introduces an all-round constant stress at infinity, and the third stress function annuls this new stress without incurring any new boundary conditions. The boundary hoop stresses are calculated for two equal size holes of varying radii, and show a maximum initial tensile stress and initial compressive stress on each hole at the near and far points from where the cut has been joined. By another suita-

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ble choice of only χ_0, a triangular wedge is cut from the origin of coordinates and extends to either circular hole, but only their common diameter and a dislocation of displacements induce a new initial stress problem when the gap is closed. This case is solved and hoop stresses determined for two equal holes in the infinite plate. D. L. Holl, USA

1861. Karunes, B., A note on the problem of dislocation in a semi-infinite plate containing a circular hole, *Indian J. Phys.* **26,** 9, 442–444, Sept. 1952.

A stress function giving the stress distribution due to a dislocation in a semi-infinite plate containing an unstressed circular hole near the straight edge of the plate is obtained in bipolar coordinates. An initial stress function χ_0 admits the possibility of a wedge-shaped fissure along the symmetry axis. An additional stress function χ_1 suitably adjusts the boundary requirements on the hole, the straight edge, and infinite boundaries. Hoop stresses on the hole and along the straight edge are determined.
D. L. Holl, USA

1862. Atsumi, A., On the stress distributions in a strip with a circular hole fitted with a rivet (in Japanese), *Trans. Soc. mech. Engrs. Japan* **18,** 68, 28–40, Mar. 1952.

The paper describes the calculation of the stress distributions in a strip with a circular hole fitted with a rivet and pulled sidewise. The method of analysis is similar to that of Howland. The traction on the circular edge is first assumed in the form $-P(1 + \cos\theta)$, $(0 \leqq \theta \leqq 2\pi)$, next in the form of contact pressure in Hertz's solution as $-P(1 - \theta^2/\alpha^2)$, $(|\theta| < \alpha)$; 0, $(|0| > \alpha)$. Precise figures and numerical tables about the stress distributions are described in each case. T. Udoguchi, Japan

1863. Saito, H., On the stress distribution in a regular polygonal plate under forces on its sides (in Japanese), *Trans. Soc. mech. Engrs. Japan* **18,** 68, 15–20, Mar. 1952.

A method is described for the calculation of stress distribution in a regular polygonal plate subjected to the forces acting in the plane on each side. Schwarz-Christoffel's conformal transformation and Muskhelishvili's method are employed. As numerical examples, three cases are treated: (1) Equilateral triangular and square plates loaded by a concentrated force in the middle of each side; (2) a square plate loaded by a concentrated tension and compression in the middle of each side alternately; and (3) a square plate loaded by a concentrated force on two opposite sides. T. Udoguchi, Japan

1864. van Wijngaarden, A., Large deflections of semi-oval rings, *Nat. LuchtLab., Amsterdam Rap.* S.313, 7 pp., 1951.

Paper presents equations and solutions for semi-oval rings, loaded in the plane of the ring and with one principal axis of inertia in the same plane. Large deflections are considered. Numerical results are given for some special cases of loading.
H. Nylander, Sweden

1865. Blaise, P., Torsion of multicellular prisms with thin walls (in French), *Ann. Ponts Chauss.* **122,** 5, 601–611, Sept./Oct. 1952.

1866. Wuest, W., Influence of the cross-section form on the behavior of Bourdon tubes (in German), *Ing.-Arch.* **20,** 2, 116–125, 1952.

Aside from the cross-section form, the behavior of a Bourdon tube for a given internal pressure depends primarily on two parameters; $\alpha = b/a$ (ratio of semi-axes of tube cross section), and $\lambda = a^2/rs$ (a major semi-axis of cross section, r bend radius of tube center line, s thickness of tube wall). For tubes with doubly symmetric cross sections the author considers the limiting case: λ finite, $\alpha \to 0$. The resulting mathematical problem is the same as that for a beam on an elastic foundation subject to a continuously varying load. An explicit solution is given for tubes with cross sections whose sides can be represented by a sixth-degree polynomial function. Numerical results are calculated for various cases, and graphs are drawn for pressure-sensitivity factor, rigidity factor for tube in pure bending, and maximum bending stress as functions of λ. The most extensive results are for cross sections with parabolic arcs for sides. Previous results [W. Wuest, *Technik* **3,** p. 23, 1948] for straight or flat-sided cross sections and finite values of α are shown for comparison. In general, the author's calculations indicate that the influence of the cross-section form increases as λ increases, and may be of considerable importance for large values of λ.

The author tacitly makes the assumption that a solution of the limit case $\alpha \to 0$ always represents a valid approximation to the actual solution for small but nonzero α. In a general sense, this assumption may be true, but the reviewer believes that, when λ is large, the validity of the approximation will depend strongly on the general type of cross section. The author's theory does not always represent accurately the behavior of a tube in the immediate vicinity of the ends of the major cross-sectional axis. As λ increases, the behavior in such regions will have increasing importance and may explain the difference for tubes of elliptical cross section between the author's results for $\alpha \to 0$ and those of E. Reissner and the reviewer for finite α [AMR **5,** 646].
R. A. Clark, USA

Buckling Problems

(See also Revs. 1831, 1877)

1867. Gerard, G., Note on creep buckling of columns, *J. aero. Sci.* **19,** 10, p. 714, Oct. 1952.

Libove's [AMR **6,** Rev. 74] analysis of creep buckling of columns indicates that initial imperfections in ordinary columns cause failure due to creep after a period of time, and shows that a theoretically perfect column loaded below the time-independent critical load will not buckle at all. Present author points out that a perfect column may be caused to buckle after a critical time if a lateral disturbance is applied at a strain rate corresponding to the local strain rate of the stress-strain curve.
D. H. Winne, USA

1868. Fung, Y. C., and Kaplan, A., Buckling of low arches or curved beams of small curvature, *NACA TN* 2840, 75 pp., Nov. 1952.

For sinusoidal arch under sinusoidal loading, critical load is expressed exactly as simple function of beam dimension parameters. For other arch shapes and load distributions, approximate values of critical load are obtained by summing a few terms of rapidly converging Fourier series. Effects of initial end thrust and axial and lateral elastic support are discussed.

Buckling load based on the energy criterion of von Kármán and Tsien is also calculated. Results for both classical and energy criteria are compared with experiments made on a series of centrally loaded, pin-ended arches. For larger values of a dimensionless parameter λ_1, proportional to ratio of arch rise to arch thickness, experimental critical buckling loads agreed quite well with classical criterion, but, for smaller values of λ_1, experimental critical loads were appreciably below those calculated from classical criterion, although they were always above those obtained from von Kármán's energy criterion.
From authors' summary by W. T. Koiter, Holland

1869. **Kromm, A., Critical shearing stress in rectangular plates with diagonal stiffeners** (in German), *Stahlbau* **21,** 10, 177–184, Oct. 1952.

Stability of a simply supported rectangular plate, reinforced by a single diagonal rib, is investigated under action of shearing stresses. The rib lies on the compression diagonal. The usual energy method is utilized in which the deflection function is represented by a double Fourier series. Coefficients in the series are evaluated for the two cases (a) where the rib remains straight and the plate buckles, and (b) where the rib deflects with the buckled plate. The "minimum stiffness" of the rib is determined, this being defined as the particular value of its flexural rigidity for which the critical shear stress of the buckled plate with deflected rib is equal to the critical shear stress of the plate with a nodal line along the diagonal. Comparison is made with the critical shear stress of a rectangular plate with a central rib parallel to the plate edge. The minimum stiffness of the rib is approximately equal in the two cases, but the critical shear stress is higher if the rib is diagonal. H. Lurie, USA

1870. **Grigolyuk, È. I., On the calculation of the stability of flat arches** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **9,** 177–200, 1951.

Author extends and completes with useful numerical data Timoshenko's paper "Buckling of flat curved bars" [*J. appl. Mech.* **2,** 1, p. 17, 1935]. Derivation of differential equations of the problem is shown in extenso. Numerical data are given for the arch with sinusoidal center line (boundary conditions: hinged ends, built-in ends, and elastic supports; load: uniform over the span, uniform partial, and concentrated).

D. Radenković, Yugoslavia

1871. **Buckens, F., Computing critical loads by splitting the rigidity of composite systems,** *J. aero. Sci.* **19,** 11, p. 787, Nov. 1952.

Author says that formula

$$P_{cr} = P_0 + (P_1^{-1} + P_2^{-1})^{-1}$$

derived by Bijlaard by his method of split rigidities [*Ingenieur Ned. Indie*, **6,** 3, 46, 1939; AMR **4,** Rev. 3518] can also be derived from general theorems given by Temple [*Proc. Lond. math. Soc.* (II) **29,** 267, 272, 1929]. Reviewer confirmed this. He remarks that Temple's mathematical theorems are found from principles of theory of integral equations. Reviewer's method is based on simple mechanical considerations and is much more generally applicable to buckling problems. In other cases [*Ingenieur Ned. Indie*, **6,** 3, 42, 1939; AMR **3,** Rev. 2622; **5,** Rev. 3367, and forthcoming papers], his method leads to equations quite different from above one. P. P. Bijlaard, USA

Joints and Joining Methods

1872. **Pecht, A., Pole connector to join pole and timber** (in German), *Öst. Bauzeitschr.* **6,** 7, 113–115, July 1951.

A special cast-steel or welded-steel connector, consisting of a pipe, ring, and three flanges, was developed and tested to transmit loads from sawed timbers to round poles in combination with a bolt penetrating the connector.

While use of a 1-in. diam bolt instead of a $^3/_4$-in. diam bolt increased the load-carrying capacity of the joint only 5%, the use of the described connector increased the load-carrying capacity 100% and resulted in a 35% saving of steel.

E. G. Stern, USA

1873. **Wilson, W. M., Munse, W. H., and Cayci, M. A., A. study of the practical efficiency under static loading of riveted joints connecting plates,** *Univ. Ill. Engng. Exp. Sta. Bull. Ser.* 402, 75 pp., July 1952. $0.75.

Description and results of University of Illinois tests in 1948 on riveted joints are included as well as those for five previous tests of riveted joints. Comparison is made between efficiencies of joints as determined by test and as determined by either of two design rules. Program included 32 test specimens. Static tests were run in a 600,000-lb Richle screw-type testing machine; pin-connected pulling heads were attached to ends of test specimen to insure centric loads.

Objectives were: (a) To determine static strength of lap joints and double-strap butt joints; each type included several rivet patterns to study their relative merit. (b) To determine effect of specimen temperature on strength and type of fracture of joint. (c) To compare test strength with that determined by various design rules.

Description of specimens and apparatus includes chemical and mechanical properties of specimen. Temperatures of tests were −20 F, room temperature (+80 F), and +120 F.

Results are tabulated and include results of 6 tests by M. Badir made at University of Illinois in 1947. Relation between temperature effect and efficiency is plotted by rivet patterns. Relative strength of double-strap butt joints and lap joints is compared. Relation between load and slip between plates is studied and plotted. Photographs of fractures are included. The efficiency of joint as determined by test is compared with that as determined by AREA design rule and the Wilson rule.

Previous tests described and re-evaluated are: (a) 1895–1896 Watertown Arsenal Tests; (b) 1926 U. S. Navy Tests by E. L. Gayhart; (c) 1930 Series University of Illinois; (d) 1932 University of Illinois by C. O. Harris; and (e) 1934 University of California tests by Davis, Woodruff, Davis.

From a plot, effective net area as determined by all tests and that by design rule indicates a maximum divergence of 13%; scatter of plot by all tests considered were 4 sq in. to 40 sq in.; ultimate strengths ranged from 248,200 lb to 2,660,000 lb. Results of 1948 tests were: (1) Specimens tested at temperatures below zero broke with a cleavage fracture; at temperatures of 120 F, they broke with a shear fracture; and at room temperature,they broke with a shear and cleavage fracture. (2) Increase in temperature caused slight decrease in efficiency for double-strap butt joints connecting $^3/_4$-in. rimmed-steel plates. (3) In most cases, efficiency of double-strap butt joints connecting $^1/_2$-in. semi-killed steel plates was 10% greater at −20 F. (4) Lap joints tested at −20 F were slightly stronger than double-strap joints at same temperature; difference, however, was not significant. (5) Tests emphasize that effective net area by test cannot be predicted accurately and that ultimate strength is not a direct function of transverse distance between rivets of outer row nor of net area at fracture section. (6) Increasing the transverse distance between rivets of outer row to more than $4^1/_2$ in. does not necessarily increase efficiency. (7) Actual efficiencies by tests reported lie between 75% and 85%. C. M. Smith, USA

1874. **Beedle, L. S., Topractsoglou, A. A., and Johnston, B. G., Connections for welded continuous portal frames. Part III. Discussion of test results and conclusions,** *Weld. Res. Suppl.* **17,** 11, 543s–560s, Nov. 1952.

Fifteen welded knee frames of structural steel, each with a different type of connection, were tested to failure. Description of tests and related theory has been given in parts I and II [AMR **5,** Revs. 410, 411]. Special attention was given to the stress distribution in the straight knee and the need for a web stiffener.

Detailed discussions for each type of connection are given in regard to the elastic strength of connections, stiffness of connections in elastic and plastic range, plastic strength, load-deformation characteristics beyond maximum load, and costs of fabrication of haunched connections.

All knees showed plastic local instability before ultimate load was reached. Premature local buckling was caused by stress concentration and residual stresses from rolling or welding. Lateral bracing was required and proved to be most effective when placed at the point where local buckling began. The importance of rotation capacity of the joint is noted when structure is to be designed for ultimate load. Difficulty in using plastic-hinge theory for frames with haunched members is discussed. Suggestions for plastic design with haunched members are given with illustrations of advantages to be gained. Detailed discussion of individual connections should be of considerable value in engineering design. S. U. Benscoter, USA

Structures

(See also Revs. 1817, 1848, 1851, 1868, 1870, 1874, 1920, 2014)

1875. Morse, W., Column analogy methods in the solution of arched beams, *Civ. Engng. Lond.* **47,** 555, 556, 557; 729–731, 828–830, 937–939; Sept., Oct., Nov. 1952.

Paper deals mainly with some routine cases of loading of circular arches; although nothing new is advanced, it could serve to make designers familiar with the method. Certain details, however, are incorrect; e.g., built-in arches must have at least 3 points of contraflexure if deformations due to normal force are disregarded, and the influence line for horizontal thrust must have horizontal tangents at the supports.

H. Craemer, Germany-Egypt

1876. Wolosewick, F. E., Flexure of double cantilever beams, *Proc. Amer. Soc. civ. Engrs.* **78,** Separ. no. 158, 11 pp., Nov. 1952.

Author treats indeterminate case of two cantilever beams, their free ends joined at an angle to form a balcony. In this general configuration, each member transmits shear, bending, and torsion. Solutions for 15 loading cases are obtained by least-work method and presented as equations in tabular form. Unfortunately, these solutions are in terms of numerous dimensionless ratios whose symbols are nowhere defined in the text and are not ASCE or ASA standards. This omission of terminology completely negates the usefulness of the paper. C. M. Tyler, Jr., USA

1877. Gábory, P., Calculation of eccentrically compressed and elastically clamped reinforced-concrete beams (columns) with straight axis taking account of buckling (in Russian), *Acta Techn. Hung., Budapest* **2,** 2/4, 391–429, 1952.

Russian concrete design specifications apparently are based on plastic theory and on load-factor methods (ultimate design) rather than on allowable stresses. Furthermore, in the design of eccentrically loaded columns, account is taken of the fact that moments and maximum eccentricities depend, among other things, not only on the stiffness but also on the axial force in the columns. Author presents the theoretical background of these specifications. The effective buckling lengths of columns with various end conditions, including elastic restraints, are derived in well-known ways (see, e.g., *Cornell Univ. Engng. Exp. Sta. Bull.* no. 36). Simplified design formulas are obtained for these lengths. Deflection and moment relations for such columns with eccentric loading are given by rederiving well-established relationships. Load criteria are developed for eccentrically loaded, elastically restrained members, based on a limiting outer-fiber stress. This case is generalized to include plasticity by introducing a variable modulus of elasticity. A straight-line relation between modulus and stress is assumed for concrete. For concentric compression, the limit load is obtained by multiplying the "limit stress" (roughly corresponding to the cylinder strength) by a reduction factor which depends on the effective slenderness ratio. For eccentric compression, the eccentricity, or the moment, is magnified by a factor which is essentially based on $1/(1 - P/P_{cr})$, that is, which again depends on the effective slenderness ratio and on the ratio of the average compression stress to the limit stress. The development is entirely theoretical and no statement is made as to comparison with tests, even on simple, eccentric columns. Two partial, numerical examples show the very considerable influence which can result, at least by this theory, from the above factors which are not accounted for in more conventional, reinforced-concrete design. G. Winter, USA

1878. Benscoter, S. U., and MacNeal, R. H., Equivalent plate theory for a straight multicell wing, *NACA TN* 2786, 32 pp., Sept. 1952.

Solution in form of nine first-order difference equations is given for thin multicell wings with straight spars and perpendicular ribs under following assumptions: Loading is reduced to concentrated forces at intersections of ribs and spars; wing is of constant depth and chord; all normal stresses are carried in flanges located at intersections of ribs or spars and skin; connecting webs carry only shear. Circuits are given for analog computation [AMR 4, Rev. 3828; 6, Rev. 709]. F. J. McCormick, USA

1879. Williams, M. L., A review of certain analysis methods for swept-wing structures, *J. aero. Sci.* **19,** 9, 615–629, Sept. 1952.

Several proposed methods for swept-wing static structural analysis are reviewed with the aim of consolidating the knowledge currently available to the structural engineer faced with the problem of a swept-wing aircraft or missile design. In addition, a fairly comprehensive bibliography on swept-wing analysis is included.

Three common types of construction—stiffened sheet, solid, and thick-walled shell structures—are discussed with respect to exact and approximate solutions for deflections and stresses. The main analytical deficiencies lie in evaluating the effect of wing-support conditions, particularly for the thick-skin wing.

It is concluded that if the structure is specified and is one of the above three types, it can in most cases be analyzed by applying or extending analysis methods now available. Nevertheless, important work yet remains to be accomplished in the field of comparative design before the optimum swept-wing structure itself can be specified.

From author's summary by R. E. Heninger, USA

1880. Schlechte, E., Internal forces in a cyclically symmetric frame of n struts from its state of deformation (in German), *Beton u. Stahlbetonbau* **47,** 9, 209–213, Sept. 1952.

Bending moments and axial forces are determined by the use of standard "slope-deflection" and equilibrium equations. Torsional resistance is ignored; hence, paper is of little value in the case of most structures. E. F. Masur, USA

1881. Hasslinger, L., Investigations on frame corners of various wood construction systems (in German), *Öst. Bauzeitschr.* 6, 8, 125–132, Aug. 1951.

Single static tests were performed on the full-size corner of three-hinged, inclined frames of 30-ft span constructed as (1) nailed I-section, (2) nailed box section, (3) glued box section with beech-plywood skin, and (4) glued arch with 61 horizontal laminations.

Strain measurements were taken to determine the stress distribution throughout the cross section. The data were analyzed and compared with strain distributions computed on the basis of Navier, Grashof-Bach, Girkmann, and Hartmann equations.

Upper-chord stresses were transmitted to lower chord through the nailed or glued web, with relatively small stresses in the outer section of the frame corner. The load-carrying capacity of the four frames was approximately the same, with factors of safety ranging between 2.5 and 3.3, the latter for the glued construction. While plastic deformation beyond the design load was observed for the nailed frames, with the nails bending and deforming the surrounding wood, straight-line deformation up to ultimate load was observed for glued assemblies.

Cost comparisons for materials and labor required for the above four construction systems were at a ratio of 100:131:196:125, respectively. E. G. Stern, USA

1882. **Rühl, K. H., Strength of metallic structural bodies in structural and mechanical engineering [Die Tragfähigkeit metallischer Baukörper in Bautechnik und Maschinenbau]**, Berlin, Verlag Wilhelm Ernst & Sohn, 1952, viii + 184 pp. DM 24.

Author presents a compilation of a number of experimental procedures and empirical formulas, and outlines methods of evaluation and calculation of stresses and deformations in various structures under various conditions. The first chapter contains a general introduction and a few definitions.

The second chapter deals with various methods of experimental determination of stresses, velocities, accelerations, and deformations. Many interesting features of mechanical, optical, and electrical apparatus and equipment are described. The analytical evaluation of experimental observations is explained. The determination of effective values and the manner of forecasting the accuracy of measurements are discussed.

In the third chapter, formulas and diagrams, together with a comparison of results obtained by other investigators, are presented for the calculation of stresses in bars and shafts containing holes, grooves, notches, and slots in tension, bending, and torsion.

The fourth chapter analyzes residual stresses; furthermore, it indicates procedures for measurements and calculation of residual stresses.

In the fifth chapter, stresses in the plastic range for perfectly plastic materials are determined for bars with a hole, notches, and with a rectangular, circular, and ring cross section in bending and torsion. Numerical problems for perfectly plastic materials illustrate the methods. Two- and three-axial stresses and the various strength theories are explained.

The sixth chapter analyzes the influence of the spatial stress system and of the residual stresses on the brittleness of the material and on the plastic deformation.

The next chapter examines the fatigue and endurance strength of the material and includes many diagrams and empirical formulas.

In the eighth chapter impact loads are treated, and a free-free as well as a built-in beam are calculated. The ninth chapter presents an interesting classification of loads and limits of strength.

In this book the practicing engineer or investigator will find ready for use and application a variety of valuable formulas, methods, and other pertinent information written in an authoritative and lucid manner. W. Ornstein, USA

1883. **Green, N. B., Bracing walls for multistory buildings,** *J. Amer. Concr. Inst.* **24,** 3, 233–248, Nov. 1952.

Method is presented for stress analysis of multistory rigid frame with relatively wide beams and columns acted upon by lateral forces, which is essentially a "portal" method analysis, with member stiffnesses modified for shear distortion. Equalizing of wall deflections is considered through joint use of portal and "cantilever" methods, incurring an inconsistency in stress distribution which is not convincingly resolved. Effect of infinite stiffness at beam-column junction is not clearly indicated. Method appears to be a quick and approximate means of evaluating contribution to lateral bracing by walls considered as structural units. G. P. Fisher, USA

1884. **Holt, Marshall, A procedure for determining the allowable out-of-roundness for vessels under external pressure,** *Trans. ASME* **74,** 7, 1225–1227, Oct. 1952.

See AMR **5,** Rev. 1028.

1885. **Swida, W., The influence of frictional forces and radial compressive forces on the prestress in reinforced-concrete structures** (in German), *Publ. int. Assn. Bridge struct. Engng.* **12,** 269–280, 1952.

Author has studied effect of friction between concrete and prestressing wires on distribution of force along the wire and of normal compressive stress between concrete and wire. Particular examples are given.

Tables are presented to enable calculation for force at any point along the prestressing wires, as a function of the force applied at the ends of the wires by the prestressing jacks, for various assumed values of the coefficient of friction between wire and concrete. F. A. Blakey, Australia

1886. **Hamann, H., Determination of the shape of stress block for a reinforced-concrete cross section subject to bending** (in German), *Schweiz. Bauztg.* **70,** 44, 629–630, Nov. 1, 1952.

Formulas are derived for determination of the shape of the stress block on the assumptions that (1) the distribution of strain is linear at all stages of loading, (2) the stress-strain relation for concrete is the same throughout the compression zone, (3) the concrete does not carry any tension. The shape of the stress block may be computed for any load, including the ultimate, if the steel stress and the stress in the concrete are known. Author uses as an illustrative example a reinforced-concrete beam tested by Bach and Graf with two concentrated loads at the third points.

I. M. Viest, USA

1887. **Birkenmaier, M., Calculation of stress losses in prestressed concrete** (in German), *Schweiz. Bauztg.* **70,** 45, 635–638, Nov. 1952.

In the design of prestressed reinforced-concrete structures, it is very important to know in advance the loss of prestress that is to be expected due to the physical qualities of concrete and steel. Author shows the well-known differential equations governing creep and retraction of concrete, together with results obtained experimentally at the Zurich Laboratory for Testing Materials (EMPA). He also gives indications respecting creep in steel, supplemented by values corresponding to different types of steel actually used in prestressing.

Formulas are derived to calculate loss of stress in centrically prestressed columns and in prestressed beams. Two numerical examples show their application. E. Rathgeb, Argentina

1888. **Robertson, R. G., Prestressed concrete beams—a rational design method,** *Struct. Engr.* **30,** 11, 259–272, Nov. 1952.

Paper deals with the ordinary theory of designing beams with posttensioned cables. The first part is devoted to simply supported beams, and the second part refers to continuous beams of

uniform symmetrical section. Formulas and design procedures are given in order to rapidly achieve satisfactory dimensions according to the permissible extreme fiber stresses. The use of theoretical relationships is illustrated with several numerical examples. Author suggests that a substantial amount of work can be saved by using the proposed method.

Reviewer makes the following comments: The usual way for an experienced engineer to determine the correct dimensions of a structural member is first to assume them in accordance with different theoretical and practical factors derived from the analysis of the problem. The use of a particular set of formulas to check the predetermined dimensions is a matter of personal preference, although all straight-line design methods tend toward identical results, with little formal differences.

It is necessary to point out some important voids in the treatment of the continuous beams. Author appears to be unaware of some of the basic theorems and rules published on the subject by Y. Guyon. Applying these theorems and rules, there is no trouble, as the author suggests, in eliminating the secondary moments, in the case of a beam of two equal spans. It is also noted that paper does not mention that the procedure given to eliminate the secondary moments was originally developed by Y. Guyon. C. A. Sciammarella, Argentina

1889. Wyly, L. T., and Lenzen, K. H., Analysis of primary and secondary stresses in the counterweight trusses of a heel trunnion bascule bridge, *Bull. Amer. Rly. Engng. Assn.* **54,** 502, 45–64, June/July 1952.

1890. Korányi, I., Reinforcement of steel bridges of mixed systems (in German), *Acta Techn. Hung., Budapest* **3,** 1/2, 179–220, 1952.

The three methods of increasing the load-carrying capacity of a steel bridge are considered to be (1) increasing the cross section of the members, (2) increasing the allowable stresses, and (3) introducing additional members. Combinations of these are usually employed and are designated as mixed systems. The author discusses the interrelationships among the three methods, and the limiting factors influencing the selection of the most economical solution for a given situation. Two examples are given in considerable detail. G. Murphy, USA

1891. Sattler, K., General theory of rhombus lattices (in German), *Bautechnik* **29,** 6, 152–159, June 1952.

Paper concerns establishment of influence lines of the bar stresses in rhombus lattices. For this kind of structure, which is said to be one of the most economical in steel construction, the usual truss theory supposing pin-ended bars is quite insufficient.

Following the work of Krabbe [*Stahlbau* 1931, p. 169], the author divides the unit load into many groups of two forces. The first group is composed of two equal forces of the same direction and is called the fundamental loading. The related stresses in the bars may be calculated by the conventional truss methods. Each of the other groups is composed of two equal and opposite forces; their number depends on the complexity of the rhombus lattice. The stresses in the bars corresponding to these loadings decrease rapidly on either side of the point of application of the external load and may be considered as corrections to the primary stresses obtained by the fundamental loading. The author simplifies the calculation of these corrections by limiting the truss to six rhombuses, three on each side of the considered section. He makes further simplifications, which reduce the number of statically indeterminate quantities and which are justified by comparison with the exact but too lengthy solution. The secondary stresses accompanying the primary ones in the fundamental loading are also evaluated by a method similar to the Cross procedure.

All these techniques are applied to the simple rhombus lattice as well as to the one-and-one-half, double, and triple rhombus. The numerical values of all the contributing stresses are given in detail for two bridge girders, the first of 230-ft span in simple rhombus and the second of 500-ft span in double rhombus.

Ch. Massonnet, Belgium

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1812, 1908, 1917, 1923, 1929, 1931)

1892. Novozhilov, V. V., On the physical sense of the stress invariants used in the theory of plasticity (in Russian), *Prikl. Mat. Mekh.* **16,** 5, 617–619, Sept./Oct. 1952.

Author considers the shear stress τ on an element of surface, whose normal against the directions of the principal components of stress is known. Forming the mean value of τ^2 over a sphere around a special point of the body and letting the radius of the sphere tend to zero, one finds the limit

$$\tau_i^2 = {}^1/_{15}\,[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]$$

The criterion of von Mises related this expression to the mean value of shear stress around the point considered. For the Lode number

$$tg\xi = \mu/3^{1/2} = [(2\sigma_2 - \sigma_1 - \sigma_3)/(\sigma_1 - \sigma_3)] \cdot [1/3^{1/2}] \qquad (-\pi/6 \leqslant \xi \leqslant \pi/6)$$

the author finds $\tau_i/\tau_{max} = (2/5)^{1/2}/\cos\xi$. Since $1 \geqslant \cos\xi \geqslant 3^{1/2}/2$, it follows $0.731 \geqslant \tau_i/\tau_{max} \geqslant 0.633$. This demonstrates that between the conditions $\tau_i = \text{const}$ and $\tau_{max} = \text{const}$ there is only a small difference. H. Schlechtweg, Germany

1893. Hill, R., On discontinuous plastic states, with special reference to localized necking in thin sheets, *J. Mech. Phys. Solids* **1,** 1, 19–30, Oct. 1952.

Discontinuous velocity fields are commonly used in problems of plane flow of a perfectly plastic solid. Across a line of discontinuity, only the tangential velocity component may be discontinuous, because the condition of incompressibility requires the normal component to be continuous. Studying discontinuous velocity fields in problems of plane plastic stress, author points out that, because of the possibility of necking, the condition of incompressibility no longer requires continuity of the normal velocity component. It is shown that the line of discontinuity must coincide with one characteristic of the stress field, while the jump in velocity at a generic point of the line of discontinuity is normal to the other characteristic. The influence of work-hardening is considered, and the critical rate of hardening is determined from the condition that the first increment of strain in the incipient neck causes an amount of hardening which will just inhibit further necking. Discontinuities of stress and surface slope and their relations to velocity discontinuities are discussed. The modes of necking of notched tension strips are investigated, and constraint factors for V-shaped and circular notches are obtained.

W. Prager, USA

1894. Mooney, M., and Black, S. A., A generalized fluidity power law and laws of extrusion, *J. Colloid Sci.* **7,** 3, 204–217, June 1952.

The fluidity power law is used as a basis for an extension to three-dimensional cases. The generalization is accomplished by assuming fluidity to be a function of the rate-of-strain tensor

which reduces to the power law in the two-dimensional case. (It is shown that the resultant law is equivalent to Nadai's three-dimensional law of steady creep, expressed in terms of the octahedral shear stress and the octahedral rate of shear.)

Using the new fluidity law, equations are derived for several cases of extrusion of a liquid such as raw rubber. Experimental results of extrusion for circular tubes are given. The data indicate an approximate agreement with the derived extrusion laws.

A. D. Schwope, USA

1895. **Fastov, N. S., Heat generation during plastic deformation** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **83,** 6, 851–854, Apr. 1952.

Author investigates theoretically whether the work of the external forces remains after unloading as heating, or as energy of the remaining plastic deformation. He assumes the latter energy of the form $W_{el}^{res} = a_1 + b_1 \Gamma + (3/2)\mu\Gamma^2 + (K/2)\epsilon^2_u$, where $\Gamma = 2/3\,(\epsilon^2_{ik} - \epsilon^2_u/3)^{1/2}$, as in most Russian literature, is designated as "intensivity" of the shear stress, and μ is the shear modulus. The work of the external forces by plastic deformation is assumed in the form $W_{pl} = a + b\Gamma + c\Gamma^2 + (K/2)\epsilon^2_u$, and at the yield point the incorrect hypothesis of continuity of the work and all the stresses is introduced.

In the special case of bending of a circular beam, author finds that the work of external forces exceeds the heating by 5%, and that its maximum is a function of yield point and modulus of shear, the slope of the supposed linear curve of strain-hardening being unimportant. H. Schlechtweg, Germany

1896. **Mii, H., Plastic deformation of light-metal bars strained with combined bending and torsion (2nd report). Theory of inverse loading,** *J. Jap. Soc. appl. Mech.* **5,** 28, 11–14, 1952.

An analysis is given for the stress and strain distribution in a round bar under reversed loading after being deformed under bending and torsion in plastic range. Plastic deformation theory with maximum shear stress-strain relation of the material as the criterion is used. The reversed bending and twist are assumed to apply simultaneously. This stress-strain relation can be empirically obtained by inverse torsion of a plastically twisted bar.

A numerical example of calculating the residual stress of a round bar after loaded in bending and twist in the plastic range is given by taking linear stress-strain relationship for the inverse loading. T. H. Lin, USA

1897. **Wain, H. L., Some observations on the yield point in zinc,** *Proc. phys. Soc. Lond.* (*B*) **65,** part 11, 395B, 886–896, Nov. 1952.

In zinc, the yield point is associated with nitrogen in solid solution. As in single crystals of iron, the yield point can be produced in nitrogen-treated zinc on the first anneal without prior deformation. By eliminating stress concentration, a difference of as much as 100% can be reached between the upper and lower yield points.

During repeated strain-aging treatments of zinc, two opposing influences on the yield point are present. The first tends to increase the yield point by work-hardening and the second tends to decrease it because of the less effective anchoring of the dislocations as the number of solute atoms available to each individual dislocation diminishes. M. J. Manjoine, USA

1898. **Mott, N. F., A theory of work-hardening of metal crystals,** *Phil. Mag.* (7) **43,** 346, 1151–1178, Nov. 1952.

Author utilizes dislocation theory to account for work-hardening of metal crystals at low temperatures. Assuming that crystal originally contains network of dislocations which may move under low stress, rapid hardening (such as occurs in cubic metals) is due to certain barriers to dislocation movement. The nature of these barriers is discussed. Based on certain assumptions, a parabolic stress-strain relation is obtained. Remarks are also made concerning dependence of work-hardening on temperature.

A. M. Wahl, USA

1899. **Warren, B. E., and Averbach, B. L., X-ray diffraction studies of cold work in metals,** "Imperfections in nearly perfect crystals," New York, John Wiley & Sons, 152–156, 1952. $7.50.

Study on severely cold-worked (70-30) alpha brass shows that the major part of broadening is due to strain-type distortion, and a minor part is due to stacking disorder and fragmentation into smaller crystals. It is found that the root mean square average stress is a function of the stress averaging distance. A new method of Fourier analysis is introduced which eliminates any assumption or preconceived models about the nature of distortion. D. Kececioglu, USA

1900. **Cazaud, R., Contribution to the study of the size effect in fatigue tests of metals. Statistical results** (in French), *Metallurgia ital.* **44,** 10, 512–517, Oct. 1952.

Paper describes an investigation on the influence of shape, size, and type of loading on the fatigue limits of some steels. In axial alternating tension-compression loading of cylindrical bars having a certain length (20 mm) of constant diameter, the fatigue limit was independent of size. Bars with a concave throat, having the same minimum cross section as the straight bars, were found to have higher fatigue limits. Further, it was found that rotation-bend loading gave higher fatigue limits than axial tension compression, whereas the difference was found to increase with decreasing diameter of the bend specimen. This is in accordance with the general experience that, for nonuniform stress distributions, the fatigue limit increases when the size is decreased, due to an increase of the stress gradient. Author refers to a theoretical explanation of these phenomena by Caquot which, in reviewer's opinion, appears somewhat doubtful. At the end of the paper, a statistical analysis shows that the dispersion of the data satisfies a Gaussian distribution and that the scatter found with the smallest bend specimen (diam 2.58 mm) is twice as large as that for the largest specimen (diam 9.6 mm).

J. H. van der Veen, Holland

1901. **Herbert, D. C., and Jenkinson, E. A., The influence of aluminum and of various heat treatments on the creep properties of low carbon steel superheater tubes,** *N. E. Cst. Instn. Engrs. Shipb. Trans.* **69,** part 1, 27–44, Nov. 1952.

The creep properties of three low-carbon steels having 1, 2, and 3 lb per ton of added aluminum, respectively, have been determined in creep tests at 8 tons per sq in. and 450 C. The tests were made on samples of tubes at various stages of manufacture, i.e., as pilgered, and after further reduction, either hot or cold. Some samples were subjected to one of various commercial annealing treatments before testing.

The steel having 1 lb of added aluminum was found to be uniformly good in creep resistance, and the steel with 3 lb uniformly poor. A study of the microstructures did not assist in classifying the steels according to creep resistance, but some indication was given by the McQuaid-Ehn test. From authors' summary

1902. **Petersen, C., Fatigue limit of structural members** (in German), *ZVDI* **94,** 30, 977–982, Oct. 1952.

Author gives a survey of ideas, hypotheses, and mathematical formulas on the relation between fatigue limit and the factors of

heterogeneity of the metal, internal notches, surface condition, stress gradient, and the size and shape of the structural member. From these formulas, the fatigue limit of a simple straight bar, provided with an external notch, can be calculated. For every more complicated structural member, a simple externally notched reference bar can be found, which will behave exactly the same under the same conditions of fatigue stress. The relation between the geometry of the reference bar and the shape and size of the structural member has been determined by experiment for several usual types of structural members (including welded connections). Undoubtedly, these data will be of interest in structural design. J. H. van der Veen, Holland

1903. Andersson, B., On the stress tensor of viscous isotropic fluids, *Arkiv Fysik* **4,** 6, 501–503, 1952.

Author discusses relation between stress and deformation-rate tensors and points out that the assumptions that (1) stress tensor is function of deformation-rate tensor and thermodynamic variables alone, (2) theory agrees with experimental results for Couette and Poiseuille flow, do not imply linear-stress deformation-rate relation, but that this must be assumed separately.
J. A. Lewis, USA

Failure, Mechanics of Solid State

(See also Revs. 1825, 1899, 1902, 1916)

1904. Nishihara, T., and Miki, H., On the change of internal friction due to repeated stresses (in Japanese), *Trans. Soc. mech. Engrs. Japan*, **18,** 71, 34–38, July 1952.

During rotating-bending fatigue tests, the logarithmic decrements of 0.1% carbon steel (cold-drawn wire rod, 3.25-mm diam) are measured by the damping method in a frequency range from 56 to 2250 cps, and the mechanism of fatigue fracture is studied from the change of the internal friction. It is concluded that the intercrystalline strain gradient induced within the material as a result of repeated stresses plays an important role, and the imperfection of the structure plays the secondary role in the fatigue failure, which sets in as microscopical cracks within the crystals in the earlier stage of the repetition of stresses and propagates itself to cause the fracture of the whole material.
T. Udoguchi, Japan

1905. Gogoberidze, D. B., and Kirvalidze, I. D., Investigation by optical methods of fatigue phenomena on monocrystals of sodium chloride (in Russian), *Zh. tekh. Fiz.* **21,** 10, 1255–1261, Oct. 1951.

Polished specimens of sodium chloride are examined in polarized light under reversed plane bending stresses. During fatigue process, double refraction is observed remaining after the test. It depends on plastic deformation of specimen. Besides, patterns of double refraction appear which vary during a cycle. Scratch parallel to cube edge and perpendicular to direction of load accelerates process of fatigue. In its neighborhood, crystal is strongly deformed, the consequence of which is a local double refraction. H. Mussmann, Germany

1906. Hilton, H. H., Creep collapse of viscoelastic columns with initial curvatures, *J. aero. Sci.* **19,** 12, 844–846, Dec. 1952.

Collapse due to creep of a viscoelastic column is investigated by using the generalized viscoelastic stress-strain relationship. An expression is derived for the ultimate time of the viscoelastic column in terms of its arbitrary initial curvature, the applied load, the material properties, and the ultimate moment of the equivalent elastic column. The results are then applied to two specific viscoelastic bodies, namely, the standard linear solid and the Maxwell body. From author's summary by T. H. Lin, USA

1907. Williams, K., Fatigue life of wing components for civil aircraft, *J. roy. aero. Soc.* **56,** 503, 842–848, Nov. 1952.

In the past, attempts have been made to correlate the estimated load variations which the component will experience during a stipulated lifetime (in hours) with estimates of the fatigue strength (in cycles of loading) for typical structural components, such as wing-spar boom joints, riveted joints, etc. The trend of thinking so far has been that one should design for a certain fatigue life. In this paper, it is shown that, even with the most careful attention given to the detail design of aluminum-alloy components, it is not possible to attain what has been regarded hitherto as the minimum acceptable fatigue strength for typical structures, based on present British Civil Airworthiness Requirements.

It is suggested that control of fatigue life by limiting the service life should be the method adopted, rather than design for a certain life. G. Gerard, USA

1908. Elsesser, T. M., Sidebottom, O. M., and Corten, H. T., The influence of aging on the Bauschinger effect in inelastically strained beams, *Trans. ASME* **74,** 8, 1291–1296, Nov. 1952.

An "aging treatment" is applied to beams under flexure in order to eliminate the deleterious Bauschinger effect (microscopic residual stresses) and to preserve the macroscopic residual stresses. It consists of loading the beams to give a predetermined amount of inelastic strain and then subjecting the beams, *while under constant load*, to a temperature of 180 F for 20 hr. This treatment is followed by unloading and loading in the reverse sense. Beams of mild steel and high-carbon steel are of rectangular cross section, and strains are measured at the outer fibers by electrical resistance strain gages.

Results show almost complete elimination of the Bauschinger effect for the mild-steel beams but only partial elimination for those of high-carbon steel.

Reviewer is unaware of any previous aging treatments on members with a nonuniform stress distribution, which are carried out while the load is maintained. Authors were limited to a temperature of 180 F because of their strain-measuring technique, but the actual temperature and "soaking" time for satisfactory aging must be dependent on the physical properties of the material and the pre-aging amount of inelastic strain. Experimental work is of high quality, producing accurate information for the type of test reported. M. C. Steele, Scotland

1909. Crook, A. W., Work-hardening of annealed mild steel under static and dynamic conditions, *Nature* **170,** 4339, 1124–1125, Dec. 27, 1952.

Using author's method of continuous measurement of force during impact loading and taking the maximum force, Meyer's hardness relations $F = kd^n$ was found to be valid for impact hardness. In static and dynamic tests with the same range of impression diameters, n was markedly lower for impact loading, from which author concludes that work-hardening is less in impact. Obviously, in order to show that n is indeed an index for work-hardening capacity, author measures Vickers hardness in center of ball impressions of unworked mild steel ($n > 2$) and finds increase with increasing impression of ball, the ratio being of the order of the ratio of Meyer hardnesses. As a further statement, it was found that after 50% precompression (almost eliminating work-hardening capacity), n in static and dynamic loading was

little different from 2, indicating at the same time that difference in n for unworked steel was not due to instrumental effects. Curiously, Vickers hardness in static and dynamic impressions of equal size did hardly differ. Author's conclusion that this apparent state of equal work-hardening is reached *after* impact seems weak. On the contrary, it shows n to be only suitable as a relative index for work-hardening capacity at equal deformation rates. J. H. Palm, Holland

Material Test Techniques

(See also Revs. 1835, 1841, 1921, 1934)

1910. **van Ouwerkerk, L., Nondestructive testing. Radioactive isotopes and their application** (in Dutch), *Metalen* **7**, 3, 5, 7, 14; 41–44, 80–87, 122–127, 233–237; Feb., Mar., Apr., July 1952.

This article reviews the methods of nondestructive testing of materials with radioactive isotopes. The nature, production, and requirements of radio isotopes employed in testing are discussed. The detection of radiation, a number of applications, and the future possible applications are discussed.
M. A. Meyer, South Africa

1911. **Hognestad, E., Inelastic behavior in tests of eccentrically loaded short reinforced concrete columns,** *J. Amer. Concr. Inst.* **24**, 2, 117–139, Oct. 1952.

As a result of tests upon 120 short-column specimens, loaded eccentrically, author proposes an inelastic theory whereby ultimate loads may be predicted. Prediction equations for ultimate loads are also developed and they check the experimental results closely. It is suggested that these prediction equations be made use of in design rooms.

The 120 specimens included tied and spiral type, of percentages varying from 1.46 to 4.25 for the tied and 4.25 for the spiral. The 28-day strength range was 1500 to 5500 psi. A 305-49 longitudinal reinforcement was used and the spiral was drawn wire. They were tested to failure by loading in 15- to 20-min increments. Strains in the steel and concrete were measured, as well as lateral deflections of the column in the plane of its eccentricity. The tests showed that, for columns of this kind and loaded in this manner, prediction equations for ultimate loads could be developed from the theory proposed.

Reviewer believes these tests have qualified research value in the development of design equations for the prediction of ultimate loads of short columns. It could help in the development of equations for the long column. As a designer, reviewer concludes that, until a more rigorous mathematically correct statement, based on inclusive tests, relating stress and strain of concrete test specimens is presented one should be careful of the extensions of these results and use of the equations. Mr. Whitney's proposed stress-distribution curve is, at best, an approximation. Next, short-time tests do not always say what a long-time test would show on a concrete test specimen. The designer is interested in this, for his design is loaded for a long time and the phenomenon of plastic flow is a consideration in his selection of a design stress. W. T. Daniels, USA

1912. **Hatfield, P., An ultrasonic phase lag method for measuring the thickness of rubber,** *Brit. J. appl. Phys.* **3**, 10, 326–328, Oct. 1952.

Apparatus is described for measuring wall thickness of enclosed rubber products in the range 5–20 mm with an accuracy of ±1 mm. Method involves reflecting 50 kcps sound wave from back surface of sample, and estimating thickness from change in phase. Quartz transducers are used as transmitter and receiver, and input and output displayed as a Lissajous pattern on a cathode-ray tube. Instrument must be calibrated with samples of known thickness, preferably of same composition as those under test, since velocity of bulk waves depends somewhat on composition (author claims this dependence is small for common rubbers, which is not true, for example, of GR-S and Butyl rubbers).
D. G. Ivey, Canada

Mechanical Properties of Specific Materials

(See also Revs. 1835, 1881, 1886, 1897, 1901, 1939, 2108)

1913. **Corten, H. T., and Elsesser, T. M., The effect of slightly elevated-temperature treatment upon microscopic and submicroscopic residual stresses induced by small inelastic strains in metals,** *Trans. ASME* **74**, 8, 1297–1302, Nov. 1952.

Authors state that slightly elevated-temperature treatment of plastically deformed metals carried out at zero load can cause (a) relaxation of microscopic residual stresses in slip bands, and (b) reduction of submicroscopic residual forces by place changes of atoms. Both (a) and (b) tend to remove the Bauschinger effect. Authors find that in brass and low-carbon steel this is also removed by slightly elevated-temperature treatment at a high stress level, during which they suggest (b) but not (a) can occur. Such heat treatment of a structural part allows the retention of the full theoretical value of favorable macroscopic residual stresses; these would be reduced by the Bauschinger effect if unloading preceded heat treatment. R. Hill, England

1914. **Hamburger, W. J., Part 1, 2; Platt, M. M., Part 3, 4, 6; Chu, C. C., Cummings, C. L., and Teixeira, N. A. Part 5; Kaswell, E. R. and Platt, M. M., Part 7; Painter, E. V., Part 8; Platt, M. M., Klein, W. G., and Hamburger, W. J., Part 9; Hamburger, W. J., Platt, M. M., and Morgan, H. M., Part 10; Mechanics of elastic performance of textile materials,** *Textile Res. J.* **18, 20, 21, 22**; 2, 12, 1, 8, 10, 5, 3, 10, 11; 102–114, 705–743, 1–15, 519–538, 539–548, 665–667, 263–276, 153–169, 641–667, 695–729; Feb., Dec. 1948; Jan., Aug., Oct. 1950; May 1951; Mar., Oct., Nov. 1952.

Parts I and II: Part I is concerned with development of quantitative measures of textile resilience. Most important quantity is *elastic performance coefficient* (EPC) in tension, defined in terms of energy absorption in initial and repeated stress-strain cycles. This coefficient reflects effect of immediate elastic deformation, and of primary (recoverable) and secondary (nonrecoverable) creep, the three components into which the author chooses to analyze the stress-strain curve. The EPC is calculated from experimental data on nylon and acetate yarns, but no demonstration is given of its value. Part II describes application of standing-wave and pulse-propagation sonic techniques to determine instantaneous elastic modulus. With aid of stress-strain curve, the three components of deformation can be obtained. Results are given for acetate, viscose, and nylon yarns.

Parts III, IV, and VI: Part III is the stress analysis of idealized model of single continuous filament yarn in tension. From yarn geometry and force-extension properties of the component filaments, breaking loads and extensions can be obtained, and force-extension curves for yarn can, in principle, be calculated. Agreement with experiment is obtained for strength and elongation as a function of twist for the acetate, viscose, and nylon yarns studied. In part VI, a similar finding is made for elastic modulus as a function of yarn twist. Part IV is the attempted analysis for a staple fiber yarn, but because of the complicated

geometry and the ignorance of fiber-interaction laws, only semi-quantitative conclusions as to effects of yarn geometry on elastic behavior are given. Predicted effect of yarn twist agrees with experiment for acetate and cotton yarns.

Part V describes development of instrument to give directly "drape coefficient" for a fabric according to authors' definition. A circular sample is draped concentrically over a circular flat horizontal plate, the ratio of projected area of overhanging portion to sample area less plate area being measured automatically.

Parts VII and IX: Part VII is a study of how elastic properties of cordage fibers are affected by mechanical treatment (knotting, combing, twist) and by ambient conditions (temperature, humidity). Part IX is an experimental study of tensile properties of yarns made from certain cordage fibers, and a theoretical study of translation of single-fiber data into yarn properties. Agreement between theory and experiment is good.

Part VIII is a set of graphs and examples to facilitate computations involved in analysis of cloth geometry according to methods of Peirce [*J. Textile Inst.* **28**, T45–96, 1937; title source, **17**, 123–147, 1947].

Part X, a somewhat diffuse paper without abstract or summary, is an introduction into the numerous complex phenomena involved in fabric creasing. Crease-recovery experiments were carried out on two sets of special fabrics (staple fiber and continuous filament) made from 3-denier cellulose acetate filaments. Some qualitative predictions on effects of yarn twist, weave, and thread count were verified, but understanding is far from complete. D. J. Montgomery, USA

1915. Picard, H. C., The irregularity of slivers: II, *J. Text. Inst. Trans.* **43**, 6, T251–T261, June 1952.

In a previous paper [AMR **5**, Rev. 1742], author derived a formula for the irregularity of a fiber assembly, as measured by the coefficient of variation in linear density. He took into account the variability in linear density both along individual fibers and between fibers, and the variability in length between fibers; the irregularity was then calculated under the assumption of random placing of fibers. Such computations are of interest in determining theoretical limits of fiber-assembly uniformity.

In the present paper, the calculation is made more realistic by taking into account the correlation between number of fibers in neighboring cross sections along the assembly, and the effect of non-random influences, such as unevenness of feed to the card or the eccentricity of rollers forming the sliver. The resulting coefficient of variation is made up of two positive terms—the first is the one found in the earlier calculation, and the second one that due to the non-random irregularities introduced externally—and a negative term attributable to the high degree of correlation between number of fibers in neighboring sections. The result embraces as special cases author's previous calculation and the formula of Vanden Abeele [*J. Text. Inst. Proc.* **42**, P162, 1951]. D. J. Montgomery, USA

1916. Bartenev, G. M., On the mechanism of fracture of rubber (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **84**, 3, 487–490, May 1952.

Specimens of two compositions were ruptured under various loads, from 8.2 to 17.0 kg/cm²; the corresponding rupture times ranged from 920 hr to 5 min. Photographs of the rupture surfaces are shown. There is a rough zone surrounded by a smooth one. Author states that the former results from slow rupture and the latter from rapid, and he interprets the observations as follows. Rupture begins at a point of weakness; it spreads at first slowly, by rupture of individual "fibers" one by one. When the tension reaches a critical value the process is completed by direct breaking of chemical bonds and is propagated at roughly the speed of sound. Author cites experimental support for the view that, in rubber, the rupture nuclei are not microscopic ruptures already present, but rather inhomogeneities, inclusions, or holes. Wm. F. Brown, Jr., USA

1917. Bartenev, G. M., On the laws of uniaxial compression and tension of rubber (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **84**, 4, 689–692, June 1952.

Author presents and discusses several sets of experimental curves for specimens of butadiene-styrol rubber, without or with added carbon. The stress vs. time curve for constant strain shows a rapid initial drop, attributed to relaxation of molecular chains, then a slow linear decrease, attributed to chemical changes. The value at the end of the rapid drop is taken as the "equilibrium" stress; the value at any specified earlier time is defined as the "static" stress at that time. If the experiment is repeated at different strains, plots of equilibrium stress or of static stress (at a specified time) vs. strain are approximately linear, if the actual area is used in computing the stress and if the strain is taken as $(L/L_0) - 1$. At constant strain rate, the stress vs. strain curves are approximately straight; the stress to strain ratio increases with strain rate. Author regards the equilibrium stress to strain ratio E_∞ and the static or dynamic ratio E (under specified conditions) as practically useful concepts; he does not investigate the stress vs. time curve analytically or discuss the relaxation mechanism in detail. Wm. F. Brown, Jr., USA

1918. Axilrod, B. M., Sherman, M. A., Cohen, V., and Wolock, I., Effects of moderate biaxial stretch-forming on tensile and crazing properties of acrylic plastic glazing, *NACA TN* 2779, 42 pp., Oct. 1952.

The materials used were commercial cast polymethyl-methacrylate sheets. The results of tests indicate that biaxially stretch-forming polymethyl-methacrylate approximately 50% does not affect its tensile strength or secant modulus of elasticity in tension. However, the total elongation and the stress and strain at the onset of crazing in the short-time tests were greatly increased by the stretch-forming. The forming also increased the threshold stress of stress crazing about 40% for loading times up to 7 days and increased the threshold stress of stress-solvent crazing with benzene about 70 to 80%. It was observed in the long-time tensile tests that the crazing cracks were more closely spaced and finer on formed as compared with unformed specimens. From authors' summary

1919. Howe, J. P., Properties of graphite, *J. Amer. ceram. Soc.* **35**, 11, 275–282, Nov. 1952.

This very condensed review of the structure and properties of graphite and carbons contains a considerable amount of information without attempting a complete coverage of the literature. Specific properties are considered from definite points of view, mostly in relation to the research performed at the General Electric laboratories. The graphite lattice, Frank's mechanism of growth of crystals, the classification of solid forms of carbons, and the electronic structure of graphite are discussed in parts II and III. It seems to the reviewer that the importance of Frank's mechanism is greatly overestimated; a serious omission is the lack of references to the series of x-ray investigations by Franklin [*Proc. roy. Soc. Lond.* **209**, 196, 1951]. In part IV, the section on thermodynamic properties (free energy, heat of sublimation, specific heat, etc.) is the most complete and contains a great number of references. Electric and magnetic properties are considered briefly, and latest unpublished results on the ther-

mal conductivity are given without references to a number of earlier papers. Lubricating properties of graphite powders and the peculiar temperature dependence of the mechanical strength of the solid carbons are discussed. Some lamellar compounds of graphite are described. The paper brings to the attention of engineers the uniqueness of the physical properties of carbons and graphite in relation to the strongly anisotopic structure of the crystallites. S. Mrozowski, USA

1920. **Higginson, E. C., Some effects of vibration and handling on concrete containing entrained air,** *J. Amer. Concr. Inst.* 24, 1, 1–12, Sept. 1952.

The amount of air lost from a concrete mix during vibration is proportional to the amount of vibration to which it is subjected. The rate of loss is very high during the first few seconds of vibration, and decreases as the period of vibration is increased. A vibrator is more effective in a small container than in a large container, and nearly all of the entrained air may be removed from concrete in small containers by vibration. Vibration removes air faster from high-slump concrete than from low-slump concrete. Regardless of wide differences in initial air content due to variable slumps, mixes containing identical amounts of air-entraining agents retain an equal amount of entrained air after 50-sec vibration. Where different amounts of air-entraining agents are used, longer periods of vibration are required to remove the air from low-slump concrete. Under usual placing conditions, the loss of air during handling and vibration of mass concrete in large open forms is not appreciable. Bleeding of concrete with or without air, as measured by laboratory tests, is reduced by vibration in periods up to 10 min. The compressive strength of concrete increases as the percentage of entrained air is decreased by vibration. The durability of concrete decreases as the percentage of trained air is decreased. From author's summary

1921. **Starkey, W. L., and Marco, S. M., Bulk modulus tests on hydraulic fluids,** Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 495–505, 1952. 8б.

Authors made thorough study of bulk modulus of elasticity of oils that might be used in hydraulically operated fatigue-testing machines. Apparatus is described in detail. Results indicate bulk modulus to be constant at any given pressure 0 to 2000 psi. Below 500 psi, entrapped gas will decrease bulk modulus. When fluid is used in hydraulic fatigue machine, effective bulk modulus is greatly decreased, due to temperature effects and possibly to gas generation. F. J. Mehringer, USA

1922. **Schevo, B. A., and Fabrykowski, Z. J., Flame hardening turret-ring ball races,** *Welding J.* **31,** 8, 699–703, Aug. 1952.

Article describes the fixture and the procedure used for flame-hardening of turret rings for the T-47 vehicle. The same principles are applicable to rings used for other purposes.

From authors' summary by H. G. Cohen, Israel

1923. **Fisher, J. C., Hart, E. W., and Pry, R. H., Theory of slip-band formation,** *Phys. Rev.* (2) **87,** 6, 958–961, Sept. 15, 1952.

Paper deals with the formation of slip bands in crystals due to plastic deformation. Frank and Read pointed out that a dislocation segment in a slip plane pinned at both ends is a source of dislocation loops, provided that the applied stress exceeds a critical stress. Based on this model, author explains the formation of slip bands and their fine structure.

A slip band contains one or more avalanches of dislocations. The fact that, with increasing stresses, only the number of the avalanches increases but not the offsets of each avalanche is due to stoppage of loop generation under the action of back stresses originating from the produced dislocation loops. When the difference between the applied stress and the back stress becomes lower than the critical stress, the production of loops is stopped, and a new avalanche will not occur immediately because the loops are partially stopped by the grain boundaries and, therefore, a portion of the back stress remains. Only if the external stress is increased or after recovery processes have reduced the back stress is a new avalanche formed. If there exists more than one slip system, the first slip plane is displaced by slips in the other systems in the inter-avalanche periods. Therefore, the slips due to succeeding avalanches in the first slip system are shifted to another. In this way, the fine structure of slip bands originates.

U. Rost, Germany

Mechanics of Forming and Cutting

1924. **Lewis, K. G., and Milne, W., Machining—theory and practice,** *Machinery, Lond.* **81,** 2083, 863–872, Oct. 1952.

A review of fundamentals of the cutting process based primarily upon the 1950 ASM symposium, "Machining—theory and practice." Chip formation, types of chips, mechanism of cutting, and power consumption are discussed. This is the first of a series of articles by the authors. H. R. Letner, USA

1925. **Spotts, M. F., Angles for machining,** *Trans. ASME* **74,** 5, 715–720, July 1952.

Paper develops methods and equations for calculating the angular settings necessary to orient some desired inclined plane surface of a workpiece into a horizontal plane properly positioned on a machine tool for machining. Solutions are given for calculating this by any one of three methods—a tetrahedron, analytical geometry, or Euler's angles. Typical equations are developed for each case and typical numerical examples are solved for orienting the workpiece on a milling machine, planer, or shaper. The methods and equations should prove useful in eliminating trial-and-error techniques and speeding up setup work on machining jobs.

M. E. Merchant, USA

1926. **Billigman, J., Determination in advance of force and power requirements in cold-working processes** (in German), *Stahl u. Eisen* **72,** 20, 1221–1230, Sept. 25, 1952.

With the aid of some simplification, approximate formulas are presented for determining upsetting pressure and upsetting capacity. The values are represented in nomograms to permit easy determination. It is assumed that the power consumption is proportional to the square of the initial diameter and an exponential function of the deformation. The actual work and the power consumption increased with the third power of the initial diameter and also an exponential function of the deformation.

The article is valuable due mostly to the straight line nomograms which permit approximate determination. They permit observation of the influence of changing conditions.

P. Grodzinski, England

1927. **Sims, R. B., and Arthur, D. F., Speed dependent variables in cold strip rolling,** *J. Iron Steel Inst.* **172,** part 3, 285–295, Nov. 1952.

Authors first discuss the effect on strip thickness of possible changes in oil-film thickness of hydrodynamically lubricated bearings, roll distortion, yield strength of the strip, and coefficient of friction in the arc of contact. They then describe an experiment on copper and steel strips which shows that the variation of the coefficient of friction between the rolls and strip is the principal cause of roll load and thickness changes with speed. Based

on these experimental results, a relationship is obtained between the average coefficient of friction and the speed of the mill.

Methods of controlling the gage of the strip during periods of acceleration and deceleration are also discussed.

B. W. Shaffer, USA

1928. Stewartson, R., The rolling of precision rounds in the U.S.A., *J. Iron Steel Inst.* **172,** part 4, 419–426, Dec. 1952.

The paper analyzes the factors that enable some American mills to produce very high quality rounds. Uniform heating and continuous production are advantages, but much of the accuracy is due to careful practice and sound mechanical design. Fabric bearings are almost universally used, partly because of good water supplies. Roller entry guides insure that leader ovals are properly held. The different pass designs used are discussed, with particular reference to the three-plug finishing pass.

From author's summary by J. Heyman, England

1929. Green, A. P., and Hill, R., Calculations on the influence of friction and die geometry in sheet drawing, *J. Mech. Phys. Solids* **1,** 1, 31–36, Oct. 1952.

Calculations of the drawing stress on the basis of the Hill-Tupper theory of sheet-drawing are reported for an extended range of angles and reductions for both smooth and rough wedge-shaped dies. The results are summarized in convenient empirical formulas. It is shown that the fractional redundant work due to inhomogeneous distortion is virtually a function only of a single geometric parameter in frictionless drawing. The redundant work does not decrease steadily as the reduction is increased, but oscillates with a decreasing amplitude. Typical die-pressure graphs for various reductions using a specific die are given. The drawing stress is found from limit-load methods. Reviewer believes the paper to be an important addition to the literature on drawing. The success of the limit-load technique will be of considerable interest to theoretical workers.

From authors' summary by J. F. W. Bishop, Scotland

1930. Anonymous, The shell moulding process. Methods employed by Polygram Casting Co., Ltd., Chiswick, *Machinery, Lond.* **81,** 2089, 1111–1116, Nov. 28, 1952.

1931. Torre, C., Power consumption in drilling (in German), *Schweiz. Arch.* **18,** 11, 351–362, Nov. 1952.

The drilling force and moment are calculated with the use of the mechanics of metal-flow criteria. Reviewer believes that this is the first thorough treatment of the drilling problem from the theory-of-plasticity viewpoint. It should serve to guide future drilling tests, because the heretofore conducted experiments are found, by the author, to be insufficient to substantiate the relationships derived in the paper. D. Kececioglu, USA

1932. Takeyama, H., Development of cutting theory into abrasion. Study of abrasive belt grinding, *J. mech. Lab., Tokyo* **6,** 4, 167–173, July 1952.

Using basic theory for orthogonal cutting, author develops expression for cutting force per unit cross section of surface layer removed by abrasion. Experimental values obtained by grinding hardened steel with 60-, 100-, 240-, and 400-grit aluminum-oxide abrasive belts at varying normal pressures are larger than those calculated from simple theory by factor of six or seven. Author attributes this to fact that theory is based upon a cutting tool with a plane face and a single cutting edge, whereas abrasive grains have random shapes. Former removes all material in front of it cleanly in chip; latter plow the surface, removing only part of the material and plastically deforming the remainder laterally. Supplemental experiment employing cutting tool of variable geometry supports author's contention.

H. R. Letner, USA

1933. Wunderlich, W., Geometric principles for milling of helical surfaces I (in German), *Öst. Ing.-Arch.* **6,** 4, 315–326, Sept. 1952.

Obscurities frequently encountered in previous publications induced author to revise existing solutions and attempt an approach corresponding to the particular needs and philosophies of the engineer. Reviewer finds the attempt has been successful. The problem is dual: (1) How to determine the profile of a milling cutter which will produce a given helical surface, and (2) how to determine the helical surface produced by a cutter of a given profile. Present publication covers first section of problem; second section will be dealt with in a subsequent issue.

Basically, a location of the cutter axis is assumed; next, the corresponding line of contact on the helical surface is sought, and subsequently, the cutter profile is determined. An initial and approximate solution is obtained through a graphical method which incidentally provides a check for the proper location of the cutter axis. Two graphical methods are described; one method consists in sectioning at right angles to cutter axis, another method uses perpendiculars to the helical surface.

The initial profile is finally examined and revised in detail by an analytical method, permitting any desired degree of accuracy. Analysis is vectorial and results in a usually transcendental equation. Various examples are worked out in detail, involving side milling cutters and an end mill. A result of interest to practically minded readers is the fact that it is possible to produce a true flat thread with sharp corners by the side mill, but not by the end mill. E. K. Henriksen, USA

1934. Bühler, H., Limitations of technological methods for the measurement of internal stresses in forgings and castings (in German), *Stahl u. Eisen* **72,** 16, 947–952, July 1952.

This paper is a critical survey of various methods to determine residual stresses in larger forgings and castings, such as for turbine shafts, turbine generator rotors, and crankshafts. To measure these stresses, samples are taken from the forging or casting. They are machined off in the form of rings or disks, or they are drilled out in the form of cylinders. Residual stresses are then obtained by strain or deflection measurements before and after the sample has been removed. It is pointed out that reliable results can be obtained only if these pieces are taken from all parts of the forging or casting. Numerous graphs are presented showing the residual stress in different sections of the piece under test. These curves show that the residual stresses near the center may be considerably higher than those near the surface; hence, many methods using test pieces obtained from sections near the surface may lead to erroneous results.

The paper contains a large number of references; the details, particularly the curves showing the internal stress as a function of the radius, should be of interest to those who are concerned with the determination of residual stresses in forgings and castings.

R. O. Fehr, USA

1935. Mace, E. W., Design of forging machine tools, *Metal Treatm.* **19,** 81, 263–264, 274, June 1952.

Author outlines design procedure for simple upset forgings. Computation is based on empirical relationship of the form $(y - 1)x \equiv 0.4$, where y is ratio of upset diameter to bar diameter and x is maximum length of upset in bar diameters. It is implied that the procedure yields a high degree of accuracy. This is

doubtful, since basic parameters such as composition of material, temperature, velocity of upsetting, flash allowance, and die friction are neglected. G. S. Cherniak, USA

1936. **Kaharl, D. J., Barrel finishing precision parts for jet propulsion units,** *Machinery, Lond.* **81,** 2088, 1067–1073, Nov. 21, 1952.

Hydraulics; Cavitation; Transport

(See also Revs. 2092, 2103)

1937. **Liu, H.-C., Free vibrations of ideal fluids in pipes with different end cross sections** (in German), *Ing.-Arch.* **20,** 5, 302–308, 1952.

A length of pipe of variable cross section is filled with an ideal frictionless fluid under gravity and closed at its lower end by a piston held elastically by a spring. The free vibrations (not necessarily small) of this system are studied on the assumption that the distribution of velocity across each section is uniform. A nonlinear differential equation of the second order is obtained, which becomes soluble when each end of the fluid column moves along a piece of constant cross section. The ratio of the two end sections is an important parameter of the motion. Author remarks that the oscillation times in opposite directions may differ significantly.

(Reviewer notes that the notation in Eq. 26 is rather misleading, as M is a function of n.) F. Ursell, England

1938. **Liu, H.-C., On vibrations of an ideal fluid in elliptic and circular communicating pipes** (in German), *Ing.-Arch.* **22,** 5, 309–314, 1952.

Author's methods (see preceding review) are applied to pipes whose center lines are circular or elliptic arcs. In the elliptic case, the section is assumed constant, and the fluid occupies the lower half of an ellipse with a horizontal axis of symmetry. In the circular case, solutions are given when the end sections are different or the same. For the latter, the motion is the same as for a simple pendulum. F. Ursell, England

1939. **Prigogine, I., and Sarolea, Liliane, On the surface tension of solutions of molecules of different sizes** (in French), *J. Chim. Phys.* **47,** 9/10, 807–815, Sept./Oct. 1952.

Results obtained by one of the authors [AMR **5,** Rev. 2401] for binary solutions composed of molecules, wherein some occupy a fixed position in a semicrystalline lattice and others are free to occupy two positions, are extended to a more general case. The case of three positions is first treated and then the case of r positions, where r is arbitrarily chosen and the molecules occupying these positions are supposed rigid. The effect of flexibility of the molecules on the surface tension is studied, as is the effect of the heat of mixing. Surface tension of mixtures of diphenylbenzene, amyl adipate - benzene, and n - octyletherpenta - ethyleneglycolbenzene have been measured. There is good agreement between calculated and experimental results. B. R. Mead, USA

1940. **Mosonyi, E., Method of determining hydraulic surface roughness** (in German), *Acta Techn. Hung., Budapest* **4,** 1/4, 325–345, 1952.

Author uses well-known theoretical formula giving surface profile in rapid flow on horizontal bottom below a sluice gate in a broad rectangular channel. When discharge, depths in two sections, and distance between sections are measured in experiments, hydraulic roughness of bottom (e.g., expressed by Manning coefficient) can be calculated. Difficulty in measuring depths in rapid flow is solved by using (1) for the upstream section the one with greatest contraction and utilizing theoretically and experimentally determined coefficients of contraction; (2) for downstream section the one just upstream hydraulic jump and eliminating depth of this section between two experiments with constant discharge and depth downstream hydraulic jump. Experiments are easily carried out in this way, and author claims to get sufficient accuracy for practical purposes, which seems to be confirmed by experimental results given. Problem of velocity distribution is not dealt with. H. T. Kristensen, Sweden

1941. **Beacham, T. E., Hydrodynamic forces on hydraulic piston valves,** *Engineering* **174,** 4528, 588–591, Nov. 1952.

With the exception of a few very brief and very qualitative remarks, this paper constitutes a condensation of the paper "Contributions to hydraulic control. 1—Steady-state axial forces on control-valve pistons," by Shih-Ying Lee and J. F. Blackburn [AMR **5,** Rev. 1116]. The original portion of the paper concerns the utilization of these steady-state forces in an automatic flow control valve. S. Z. Dushkes, USA

1942. **Elder, R. A., and Dougherty, G. B., Characteristics of fixed-dispersion cone valves,** *Proc. Amer. Soc. civ. Engrs.* **78,** Separ. no. 153, 21 pp., Nov. 1952.

Authors describe and give rating curves based on prototype observations for large fixed-dispersion cone valves used in conjunction with energy-dissipating structures of several TVA dams. Information is also presented on the design of the energy-dissipating structures used with the valves. Data on the air/water ratio for both open and closed discharge valves are presented.

W. M. Owen, USA

1943. **Viparelli, C., On dimensioning of collector canals with surface discharge** (in Italian), *Energia elett.* **29,** 6, 341–353, June 1952.

Author summarizes the research work done for the Boulder Dam collector canal [*Bur. Reclamation Bull.* I, Denver, 1938]. The first project, based on the proposals of J. Hinds [*Trans. Amer. Soc. civ. Engrs.* **89,** 1926], and the modifications to this project (based on model tests by the Bureau of Reclamation) for avoiding excessive turbulence and air entrainment are commented upon. Similar tests were made by the author when designing a collector canal for an Italian power station. Author compares his solution with that of Denver and adds some calculations, using the equation of momentum in a direction perpendicular to the canal axis. In the direction parallel to the canal axis, he uses a theory developed by Nebbia instead of the equation of momentum introduced by all the authors who have dealt with this problem previously. C. Jaeger, England

1944. **Parmakian, J., Pressure surges at large pump installations,** ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-60, 8 pp., 3 tables, 16 figs.

Paper summarizes results of graphical solution of water-hammer equations and compares them to experimental results for three installations. Good checks are obtained on maximum pressures and pump speeds (reversal of pumps existed in most cases).

D. F. Gunder, USA

1945. **Ippen, A. T., and Harleman, D. R. F., Certain quantitative results of the hydraulic analogy to supersonic flow,** Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 219–230, 1952. 86.

For isentropic processes, classical hydraulic analogy applies

only to nonexistent gas having isentropic exponent 2; if shocks are present, analog gas is one having variable exponent which depends on shock-density ratio. Hence, analogy cannot give completely accurate results for air. Paper proposes a modified theory in which hydraulic depth ratio is used only to obtain analogous density ratio; pressure, temperature, and other characteristics are then obtained by aerodynamic calculation. Tests and comparisons indicate that basic analogy is sufficiently good if only force and moment coefficients of airfoil shape are desired, since only pressure differences are involved and discrepancies tend to cancel out. However, modified analogy is necessary to obtain actual pressure distributions and other characteristics. C. W. Smith, USA

1946. Iversen, H. W., Laboratory study of breakers, "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 9–32, 1952. $1.75.

Laboratory results are presented for the transformation of wave heights as a function of depth in a wave system in a steady state of oscillation. The small amplitude theory is shown to be inadequate for laboratory wave channel work to enable evaluation of the true deep-water wave from a shallow-water wave-height measurement.

Breaker geometrical relationships are established for plane impervious beaches with slopes from 1:10 to 1:50. In this range, the beach slope has a marked effect upon the breaker in that, for a given wave train, the breaker is approximately 40% higher on a 1:10 slope as compared to a 1:50 slope. The breaker on a 1:10 slope is also steeper in front and flatter in back, with a greater tendency to plunge.

From author's summary by R. S. Arthur, USA

Incompressible Flow: Laminar; Viscous

(See also Revs. 1802, 1822, 1823, 1939, 1969, 1974, 1984, 1989, 1998, 2004, 2008, 2048, 2064, 2090)

1947. Manwell, A. R., Constant velocity aerofoils with circulation, *Proc. Lond. math. Soc.* (2) **54,** 168–183, 1952.

Riabouchinsky [title source, **19,** 206–215, 1920] derived airfoil profiles for constant pressure distribution; these are symmetrical profiles at zero lift. Manwell [AMR **2,** Rev. 326] showed that these are minimum-velocity airfoils for given thickness ratios. Here the Riabouchinsky series is generalized to provide different constant values of the pressure on upper and lower surfaces and thus circulation and lift. The method makes use of the hodograph plane and there is the usual problem of assuring that the profiles are closed. These airfoils with lift do not have the property of minimum velocity for given thickness ratio. This the author proves by considering the special case of an infinitesimally thin member of the series, with infinitesimal lift. He points out that minimum-velocity profiles with lift need not have constant velocity on their lower surfaces, and conjectures that the maximum velocity may occur somewhere on their lower surfaces as well as on their upper surfaces. W. R. Sears, USA

1948. Nitzberg, G. E., and Crandall, S. M., A comparative examination of some measurements of airfoil section lift and drag at supercritical speeds, *NACA TN* 2825, 30 pp., Nov. 1952.

Semi-empirical correlations of pressure drag at drag-rise Mach speeds (supercritical Mach speed) were made for a family of symmetrical sections and several cambered sections at angles of attack ranging from $-2°$ to $+6°$. Drag coefficients of the form $C_Dq/P_0 = (\gamma/2)(P/P_0)(C_DM^2)$ were used and an essentially unique drag-rise curve is found at the angle of attack for the drag-rise maximum critical Mach speed (M_{cr}). Section shape appears only to affect the magnitude of M_{cr}. The transonic similarity rules appear to give accurate correlation only when there is also good correlation of the M_{cr}. Thus, a translational adjustment in the similarity parameter to correct for poor correlation in M_{cr} improves the range of usefulness of the similarity rule.

The section lift study showed that lift losses at drag supercritical speeds were chargeable to that surface of the section which had only subsonic flow. This loss effect decreased with decrease in thickness ratio, and, hence, the transonic similarity rule should be applicable for thin sections.

M. G. Scherberg, USA

1949. Lagerstrom, P. A., and Van Dyke, M. D., General considerations about planar and non-planar lifting systems, *Douglas Aircr. Co., Rep.* SM-13432, 80 pp., 1949.

Report deals with a semi-quantitative treatment of wing-body interference problems for supersonic flow. Part I deals extensively with so-called planar systems made up essentially of wings alone. In part II, the combination of plane wings and simple bodies is considered. The general approach to the work is that of establishing trends for interference effects based on linearized supersonic flow theory before proceeding to more elaborate considerations of wings and bodies alone on the basis of second-order and other more exact theories. M. J. Thompson, USA

1950. Sims, J. L., and Schnitzer, E., A theoretical investigation of the effect of partial wing lift on hydrodynamic landing characteristics of V-bottom seaplanes in step impacts, *NACA TN* 2815, 20 pp., Nov. 1952.

One more step has been taken in this report toward the complete physical picture of water landings. The theory in this paper covers loads and motions in water-landing impacts of wide prismatic V-bottom seaplanes for constant partial wing-lift conditions where the resultant velocity of the seaplane is normal to the keel. An approximate method is given for applying the results of this investigation to the more general case of oblique impact. The increase in vertical hydrodynamic load factor is shown to be approximately 133% of the decrease in wing lift, and this effect is most important for large seaplanes that have been designed for low impact loads. Still omitted in this analysis are planing effects and effects of buoyancy in the water.

W. C. Johnson, Jr., USA

1951. Klunker, E. B., and Rennemann, C., Jr., Effect of a finite trailing-edge thickness on the drag of rectangular and delta wings at supersonic speeds, *NACA TN* 2828, 26 pp., Nov. 1952.

Linearized theory is used to calculate drag of rectangular and delta wings having truncated diamond-shaped sections. Results show that, for given thickness ratios, drag at high Mach numbers is less for trailing edges with finite thickness than for sharp trailing edges. G. N. Ward, England

1952. Shestopalov, V. P., On a particular solution for a heat boundary layer in a diffuser (in Russian), *Prikl. Mat. Mekh.* 16, 5, 613–616, Sept./Oct. 1952.

Author seeks a boundary-layer solution for an incompressible source flow with constant wall temperature such that outside the boundary layer the velocity is $(Q/\alpha r)$ and in the boundary layer the velocity is proportional to $(Q/\alpha r)$, but otherwise a function of the similarity parameter (y/x) only. The velocity profile is then computed in closed form, and the temperature is a hypergeometric function of a variable associated with the velocity.

L. Trilling, USA

1953. **Kufarev, P. P., On the flow around a circular arc** (in Russian), *Prikl. Mat. Mekh.* **16**, 5, 589–598, Sept./Oct. 1952.

The problem of symmetric flow of an incompressible inviscid fluid around the convex side of a circular arc can be reduced to the solution of an integrodifferential equation for a function, from which the complex potential of flow is obtained by quadratures. It is shown that, for small arc lengths l, the equation has a unique solution which is holomorphic in the neighborhood of the arc. The calculations are relatively simple and yield, in the case of very small arcs, for the drag coefficient C_D the equation

$$C_D = 2\pi(1 + 0.095l/R)/(\pi + 4)$$

where R is the arc radius. A. Kuhelj, Yugoslavia

1954. **Kawaguti, M., On the viscous shear flow around a circular cylinder** (in Japanese), *Rep. Inst. Sci. Technol. Tokyo* **6**, 2, 85–91, Apr. 1952.

A circular cylinder of unit radius in a uniform shear flow $U = 1 + \alpha y$ of viscous fluid is considered. Author solves the second approximation of the Stokes equation for the flow region $1 < r < R$ with the condition that, at $r = R$, the viscous flow smoothly goes over to the shear flow with circulation around the same circular cylinder. The lift and drag of the cylinder are calculated, assuming either $R = A/Re$ or $R = B/Re^{1/2}$, where Re is the Reynolds number, and A, B are appropriate numerical constants. Further, pressure and vorticity distributions on the surface as well as flow patterns around the cylinder are given for $Re = 2$ and $\alpha = 0, 0.1, 0.5$, taking $R = 10$.

I. Imai, Japan

1955. **Andrade, E. N. da C., Viscosity of liquids,** *Proc. roy. Soc. Lond.* (*A*) **215**, 1120, 36–43, Nov. 1952.

Author's experimental results enable him to check the viscosity of monomolecular metals near the melting point against various formulas, of which

$$\eta = 5.7 \cdot 10^{-4} \cdot T_M^{1/2} \cdot \rho^{2/3} \cdot A^{-1/6}$$

best describes the results, especially with a slightly changed constant; ρ is density, A atomic weight, T_M melting temperature in °K. The variation of the viscosity with temperature seems to be best described by

$$\eta = (C/v^{1/3})\, e^{c/vT}$$

with C and c constants, v specific volume, T temperature. The constants change systematically with the atomic weight. Using extreme accuracy in the measurements, he shows that the last relationship changes abruptly in the region of supercooling.

H. A. Einstein, USA

1956. **Sretensky, L. N., Motion of a cylinder under the surface of a heavy fluid,** *NACA TM* 1335, 37 pp., Nov. 1952.

Translation from *Cent. Aero-Hydr. Inst. Trans.*, Rep. 346, 1938.

1957. **Ellis, G. O., and Stanitz, J. D., Comparison of two- and three-dimensional potential flow solutions in a rotating impeller passage,** *NACA TN* 2806, 61 pp., Oct. 1952.

Incompressible, nonviscous, potential flow in a rotating impellor passage is considered. Numerical procedure used in obtaining three-dimensional solutions for the flow is outlined. Solutions are presented for (1) zero flow through the rotating passage, (2) flow through the stationary passage, and (3) two ratios of through flow to impeller tip speed.

Authors compare results with corresponding two-dimensional solutions and conclude that two-dimensional solutions can be combined to describe three-dimensional flow with satisfactory accuracy, at least for cases considered. S. F. Gilman, USA

Compressible Flow, Gas Dynamics

(See also Revs. 1936, 1945, 1948, 1980, 1982, 1990, 1992, 1997, 2015, 2029, 2030, 2038, 2049, 2058, 2068)

1958. **Eggers, A. J., Jr., On the calculation of flow about objects traveling at high supersonic speeds,** *NACA TN* 2811, 25 pp., Oct. 1952.

The characteristics method with three independent variables is applied for solving steady three-dimensional supersonic flow problems. The flow is assumed to be adiabatic and inviscid, but rotational flow and thermal and caloric imperfections are admitted, because these features of generality are important in the case of hypersonic flow. A rather simple form of the compatibility equations is obtained by introducing pressure and flow inclination angles as independent variables. Application of the method to steady problems seems to be feasible with the aid of high-speed computing machines. Extension of the method to nonsteady three-dimensional problems, being formidably tedious and time-consuming, is outlined briefly. Specific purpose of the paper is the development of an approximate method for the hypersonic range. This method may have practical value for computing flow around missiles at high supersonic speeds. Hypersonic similarity parameters are employed. It is pointed out that, under certain circumstances, flow in the osculating planes of streamlines is of the generalized Prandtl-Meyer type, and surface streamlines may be approximated by geodesics. These results hold both for steady and nonsteady flow around sufficiently slender shapes. Author concludes from such considerations "that two-dimensional flow equations may be applicable to a relatively wide class of flows at high supersonic speeds."

R. Sauer, Germany

1959. **Tribus, M., and Guibert, A., Impingement of spherical droplets in a wedge at supersonic speeds in air,** *J. aero. Sci.* **19**, 6, 391–394, 403, June 1952.

The deflection of droplets in the uniform stream behind a wedge in supersonic flow with attached shock wave is investigated theoretically, making use of known data on the drag of drops in air as a function of Reynolds number. The necessary formulas and graphs are given for calculation of rate of deposition as function of distance from the leading edge, wedge angle, Mach number, drop size, and Reynolds number of relative flow. Contrary to the subsonic flow case, there is no limiting position beyond which deposition does not occur. An example is worked out.

A. M. Kuethe, USA

1960. **Kolodner, I. J., Reiche, F., and Ludloff, H. F., Corrections for drag, lift, and moment of an axially symmetrical body placed in a supersonic tunnel having a two-dimensional pressure gradient,** *NACA TN* 2837, 45 pp., Nov. 1952.

An axially symmetrical body is placed in a supersonic flow having a two-dimensional pressure gradient of special, relatively simple type. Assuming irrotational conditions, the velocity potential of the flow is expanded in a threefold manner; (1) in powers of the thickness parameter of the body, (2) in powers of a parameter characterizing the inhomogeneity of the basic flow field, and (3) as a Fourier series in the azimuth around the body axis. Each expansion is taken into account no further than up to the second term. The analytical treatment becomes rather difficult

because of the difference in symmetry between the body and the basic flow field.

The drag, lift, and moment corrections for arbitrary body shapes are obtained in closed analytical form. The physical meaning of the results and their validity are discussed.

From authors' summary by T. R. Gullstrand, Sweden

1961. Wylly, A., A second-order solution for an oscillating two-dimensional supersonic airfoil, *J. aero. Sci.* **19,** 10, 685–696, 704, Oct. 1952.

By iteration, a solution valid to second order in angle of attack and thickness is obtained for airfoils of arbitrary cross section. A first-order velocity potential is derived which is a power series approximation, in frequency, to the exact linearized solution and which is, moreover, suitable for iteration.

Next, a second-order solution, in angle of attack and frequency, is developed. It appears that the second-order terms in many cases reverse the tendencies indicated by first-order theory. An example for the theoretical instability as related to thickness is added. Comparison with British experiments on the damping moment show much better agreement than linearized theory.

From author's summary by A. van Heemert, Holland

1962. Glass, I. I., The design of a wave interaction tube, *Inst. Aerophys. Univ. Toronto Rep.* no. 6, 136 pp., May 1950.

Report describes construction and operation of a shock tube and drum camera for schlieren observation of one-dimensional wave interactions. A 1-in. ID pipe in three sections is provided with clamps for holding cellophane diaphragms at each end of center section. This has 25-in. long lucite observation window. Tube is on rollers so that any 12-in. portion may be observed at one time. The schlieren system focuses through a horizontal slit onto film placed on a rotating drum. Film speed is 220 fps. Very complete and careful details are given on all auxiliary devices needed to record data and operate the equipment. Preliminary measurements on the velocities of the incident shock and cold front are compared with theory. The deviations observed at large shock strengths have since been found to result largely from measurements taken too close to the diaphragm. Further experiments are made on waves reflected from a rubber membrane, shock-cold front interactions, and head-on collisions of shocks and of rarefactions. References to the theory of shock tubes that are perhaps more accessible than those given are AMR **4,** Revs. 307, 336. W. Griffith, USA

1963. Lobb, R. K., On the length of a shock tube, *Inst. Aerophys. Univ. Toronto Rep.* no. 4, 20 pp., 11 figs., July 1950.

The maximum duration between the arrival of the shock wave and arrival of other disturbances is found at that position in the shock tube where the reflected expansion wave from the compression chamber overtakes the contact surface. Similarly, the maximum duration between arrival of the contact surface and arrival of other disturbances is found at that position where the head of the reflected expansion wave overtakes the tail of the initial expansion wave. The ratio of these intersection distances to compression-chamber length is computed as function of pressure ratio for several gas-gas interfaces. The minimum shock-tube lengths required to avoid reduction in these maximum durations due to the reflected shock wave are also presented.

W. E. Moeckel, USA

1964. Kawamura, R., Study of axially symmetric supersonic jets with special regard to the shock waves in them (in Japanese), *Rep. Inst. Sci. Technol. Tokyo* **6,** 3, 141–148, June 1952.

The first shock configuration in a supersonic air jet issuing from a circular orifice of 2.2-cm diam is studied by the schlieren method. Change of shock configuration from conical to dish-typed is found to take place at $p_A/p_T \doteqdot 0.3$, where p_A is the atmospheric pressure and p_T the tank pressure. The position of the shock, the diameter of the dish-typed shock, and the angles between the three shocks in the dish-typed configuration are measured. Analysis of these data shows that the usual Mach reflection theory can describe the dish-typed configuration satisfactorily in the case of higher values of p_A/p_T (such as 0.251), but not for lower values of p_A/p_T (such as 0.175).

I. Imai, Japan

1965. Ritter, A., and Kuo, Y.-H., Reflection of a weak shock wave from a boundary layer along a flat plate. I—Interaction of weak shock waves with laminar and turbulent boundary layers analyzed by momentum-integral method, *NACA TN* 2868, 66 pp., Jan. 1953.

In contrast to Lighthill's theory [AMR **4,** Rev. 4218], viscosity effects are taken into account by connecting the vertical velocity of the outer flow with the streamline deflection, as given by the displacement thickness of the boundary layer. The momentum integral (with some simplifications) relates the displacement-thickness perturbation to the velocity perturbation along the edge of the boundary layer which is propagated upstream and downstream in the subsonic layer. Matching of the boundary-layer flow and the outer flow gives the constants of integration.

In the laminar case, the pressure disturbance along the wall decreases exponentially upstream of the point of incidence of the shock wave; for a Mach number of 2 and a Reynolds number of 1500 (for the displacement thickness), the upstream influence is of the order of 30 displacement thicknesses. Downstream the pressure overcompresses and then falls to the value corresponding to regular reflection. The exponential pressure rise appears to be verified in the case of a shock deflection angle of 1°, since separation has probably not occurred, which is not accounted for in the present theory. If separation occurred, the separation point moved upstream with increasing shock strength and Reynolds number, yet with decreasing Mach number.

The turbulent case is treated only briefly, since here the reflection is practically the same as that for a regular reflection in nonviscous flow. K. Wieghardt, Germany

1966. Bond, R., and Goldsmith, W., A chart for oblique shock waves in water, *J. appl. Mech.* **19,** 4, 558–560, Dec. 1952.

This paper gives data which facilitate calculations on oblique shock waves in sea water; the data are shown as lines of constant pressure, of constant deflection angle, and of constant final Mach number, plotted on rectangular coordinates of initial Mach number and flow angle. The data are based on the computations of Arons and Halverson [OSRD 6577, 1946] for water of salinity 32 parts/thousand at 25 C. The curves show the same general features as the corresponding curves for shock waves in air; the main difference consists in the larger pressures and the smaller deflection angles which occur in water shock waves.

R. M. Davies, Wales

1967. Hess, R. V., A study of the transient behavior of shock waves in transonic channel flows, *NACA TN* 2797, 32 pp., Oct. 1952.

The accuracy of the result obtained in a fundamental paper by Kantrowitz [AMR **1,** Rev. 682], that a small short-time lowering of the back pressure in steady shock-free transonic diffuser flow causes a stationary or trapped shock to form near the critical sonic channel throat, is investigated by considering the contribution of a higher-order term in the short-time calculations, which

was neglected in Kantrowitz's paper. In this more accurate approximation to the short-time effects, the shock is no longer stationary or trapped unless it is supported by a negative steady-flow back pressure. The inclusion of the higher-order term in the short-time calculations avoids the use of approximate quasi-steady-flow considerations for the complete diffuser flow to increase the accuracy of the shock motion, as was required in Kantrowitz's paper. In a broad sense, the present paper offers a firmer basis for the short-time approach originated in Kantrowitz's paper.

The present results transform into those previously reported [Hess, AMR **3**, Rev. 1328] for amplitudes that are small compared to the difference between local and critical sonic velocities of the channel flow.

From author's summary by G. C. Quigg, Australia

1968. **Kaplan, C., On a solution of the nonlinear differential equation for transonic flow past a wave-shaped wall,** *NACA Rep.* 1069, 11 pp., 1952.

Supersedes article reviewed in AMR **4**, Rev. 4046.

1969. **Kaplan, C., On transonic flow past a wave-shaped wall,** *NACA TN* 2748, 43 pp., Aug. 1952.

Present paper extends work of previous paper [AMR **4**, Rev. 4046]. Power-series solution of two-dimensional steady transonic equation for flow past an infinite sinusoidal wall is studied. The assumed solution implies a symmetric shape for any supersonic zones which occur. A test for convergence is devised which shows that the series solution diverges whenever the local Mach number is supersonic. The conclusion is that smooth potential flow with a supersonic zone is not possible for the sinusoidal wall, hence probably for any airfoil. Reviewer believes the conclusion is correct, but also that a complete theory should explain why the many smooth solutions obtained by the hodograph method are not realistic.

J. D. Cole, USA

1970. **Gullstrand, T. R., The flow over symmetrical aerofoils without incidence at sonic speed,** *Roy. Inst. Technol. Div. Aero., Stockholm, KTH-Aero TN* 24, 39 pp., Mar. 1952.

Oswatitch's method [AMR **4**, Rev. 302] appears not to hold for sonic speeds. Use is made of equation $V^2\phi = M^2U + M^2[1 + (k-1)M^2/2]U^2$ (U is perturbation velocity, M Mach number in infinity, $k = c_p/c_v$) to obtain, by means of Green's theorem, a nonlinear integral equation, holding for transonic flow, even in presence of weak shock waves. To solve equation, it is necessary to make some plausible assumptions for the velocity distribution in the region of integration. Discussion of properties of flow at sonic speed and application to symmetrical aerofoils at zero lift are made. Author states that results agree with experiments.

G. Moretti, Argentina

1971. **Meyer, R. E., On waves of finite amplitude in ducts. Part I. Wave fronts. Part II. Waves of moderate amplitude,** *Quart. J. Mech. appl. Math.* **5**, part 3, 257–291, Sept. 1952.

Part I. In a slowly converging-diverging nozzle, the steady flow free from shock is supposed to be subjected to pressure disturbances at its exit or entry. It is treated as one-dimensional nonlinear theory of inviscid compressible fluid. All compression (not expansion) wave fronts show an initial tendency to shock formation. It is also found that the receding wave fronts at exit traveling upstream in the so-called diffuser flow (supersonic being upstream, and subsonic downstream of the sonic throat) are caught at the throat. During the trapping process, the accumulated disturbances may lead to shock formation and breakdown of the diffuser flow, provided the cross section increases more strongly than tenth power of the distance from the throat ($\gamma = 1.4$). This explains the instability of the diffuser flow. In the so-called nozzle flow (subsonic being upstream and supersonic downstream of the sonic throat), all the wave fronts and the possible shocks formed will, on the other hand, blow off of the dust immediately. So it is stable. Criticisms of Brown's incompatible assumptions and Kantrowitz's neglecting terms of $(M-1)$ are made.

Part II. The results of part I are extended to a first-order theory of advancing and receding waves traveling into steady shock-free flow of inviscid perfect gas in a duct of slowly varying cross section. This includes, as special cases, spherical waves and waves with cylindrical symmetry.

The theory applies (1) to the neighborhood of any wave front traveling into steady, shock-free flow, and (2) to waves caused by any disturbance of finite duration and extent such that the velocity and pressure differ little from their respective local values in the steady flow. No assumption is implied that the local rates of change of velocity and pressure are small, and shock waves may form. Only a partial solution, however, is given for the interaction of an advancing wave with a receding wave of comparable strength.

In a first approximation, the fluid acceleration, the local rate of change of pressure, and the limit lines are found. A second approximation gives the velocity and the pressure and the shock path, to the first order in the shock strength.

From author's summary by C.-C. Chang, England

1972. **Li, T.-Y., and Nagamatsu, H. T., Effect of density fluctuations on the turbulent skin friction on a flat plate at high supersonic speeds,** Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 263–275, 1952. $6.

Following Prandtl's mixing-length concept, authors express both parts, namely, contributions due to density fluctuations and velocity fluctuations, of the Reynolds shear in a turbulent flow in terms of the gradients of mean density and velocity, involving mixing length and a compressibility mixing parameter. By assuming that Prandtl's mixing length, even in this case, is independent of the compressibility effects, a skin-friction law is derived for an insulated flat plate as function of Reynolds and Mach numbers and the compressibility mixing parameter. The variations of the skin friction with Mach number for different values of the compressibility parameter are given and compared with von Kármán's formula. No comparison with experiments is made.

Y. H. Kuo, USA

1973. **Martin, J. C., Margolis, K., and Jeffreys, Isabella, Calculation of lift and pitching moments due to angle of attack and steady pitching velocity at supersonic speeds for thin swept-back tapered wings with stream-wise tips and supersonic leading and trailing edges,** *NACA TN* 2699, 116 pp., June 1952.

Analyses according to linearized theory and data are presented in the form of design charts for stability derivatives C_{m_α}, C_{m_q}, and C_{L_q}. Results are valid for Mach numbers above those for which Mach lines from center section of wings do not intersect tips, and the foremost Mach line from either tip does not intersect remote half of wing. Reviewer notes that no mention is made of well-known significant second-order effect on moments.

A. H. Flax, USA

1974. **Graham, E. W., A drag reduction method for wings of fixed planform,** *Douglas Aircr. Co. Rep.* SM-14441, 11 pp., July 1952 = *J. aero. Sci.* **19**, 12, 823–825, Dec. 1952.

By suitably twisting and cambering a wing, an angle-of-attack distribution may be found for which the induced drag in super-

sonic flow is a minimum at a given lift. Author presents a method of approaching this optimum angle-of-attack distribution. After two independent types of distribution have been chosen, the method selects the optimum superposition of the two distributions as determined by linear theory. Further improvement is obtainable by considering additional types of angle distribution. The method is easily applied when planform and chosen angle distribution are simple. Theoretical reductions in drag of up to 36% are reported for low-aspect-ratio wings. Unlike Jones' method [*J. aero. Sci.* **19**, 12, 813–822], the present method yields only an approximately optimum angle distribution. In general, a distribution would be optimum for only one angle of attack and Mach number. The method may also be applied to reduce the drag due to thickness. L. H. Schindel, USA

1975. LaBerge, J. G., Design calibration and correction of a 1.6 Mach number nozzle, *Nat. aero. Establ. Canad.*, LR-41, 7 pp., 3 tables, 12 figs., Nov. 1952.

An improvement in the working-section flow distribution was achieved by applying to nozzle liners a profile correction calculated on the basis of originally measured pressure distribution. The Mach number variation was reduced from ± 2.2 to $\pm 0.9\%$, giving a final mean Mach number of 1.640. A further improvement in working-section flow distribution could be obtained by again correcting the nozzle profile, but the degree of flow uniformity achieved is regarded at present as satisfactory.

From author's summary

1976. Pack, D. C., Hodograph methods in gas dynamics (Lecture series no. 17, edited by Roth, H.), Univ. Maryland, Inst. Fluid Dynam. appl. Math., 59 pp., 1951/1952.

The mathematics of the hodograph method proposed independently by Cherry [AMR **2**, Rev. 1165] and Lighthill [AMR **3**, Revs. 931, 932] is described in detail. This covers four of the six lectures. In the other two, the basic hodograph equations and some of their simple particular solutions are discussed.

H. Yoshihara, USA

1977. Lee, J. D., Design and performance of a small Mach-Zehnder interferometer, *Inst. Aerophys. Univ. Toronto Rep.* no 20, 7 pp., 11 figs., Oct. 1952.

Turbulence, Boundary Layer, etc.

(See also Revs. 1943, 1972, 2025, 2027, 2028, 2048, 2090)

1978. Moore, F. K., Laminar boundary layer on cone in supersonic flow at large angle of attack, *NACA TN* 2844, 34 pp., Nov. 1952.

The same author has previously calculated the laminar boundary layer on circular cones at small angles of attack [AMR **5**, Rev. 1157]. It was shown from the form into which the boundary-layer equations were cast that velocity, pressure, and density are constant along parabolas drawn in meridional planes. Viscosity is assumed to be linearly related to temperatures; Prandtl number is 1; ratio of specific heats is constant; there is no heat transfer through surface of cone. The equations are nonlinear and difficult to solve in general. A solution for the plane of symmetry alone is undertaken.

As potential-flow values, data computed by Kopal and associates [*M.I.T. Tech. Reps.* 1, 3, 1947; 5, 1949; also AMR **3**, Rev. 935] are used. In these tables, the words "large yaw" meant only that quadratic terms in angle of yaw were retained, higher terms being neglected; the limitations implied here are discussed, as are the comments of Ferri [AMR **4**, Rev. 1650] regarding the entropy layer at the cone. In the latter connection, it is concluded that only Mach numbers, cone angles, and angles of attack can be treated for which nearly isentropic flow can be assumed. The equations for the regions at both top and bottom of a 7.5° cone in the plane of symmetry have been solved numerically by Lynn Albers for Mach number 3.1 and several angles of attack. Skin friction and displacement thickness for the bottom of the cone are plotted against angle of attack.

At the top of the cone, the solution becomes indeterminate at angles of attack above very small ones, and fails to exist at all at still larger angles, of the order of the semi-vertex angle. The reasons for these difficulties are discussed extensively. Author concludes that the indeterminacy results when the growth of the boundary layer along the top in the plane of symmetry becomes dependent on the layer over the rest of the cone; i.e., a solution for this plane alone is impossible. The nonexistence is related to nonexistence of an asymptotic solution for large values of the boundary-layer coordinate normal to the surface; it was pointed out by Hayes [AMR **5**, Rev. 195]. This phenomenon implies that a boundary layer in Prandtl's sense does not occur. There is a discussion here of the meaning of separation in three-dimensional flows in general and in the yawed cone in particular.

W. R. Sears, USA

1979. Torda, T. P., Boundary layer control by continuous surface suction or injection, *J. Math. Phys.* **31**, 3, 206–213, Oct. 1952.

Author applies von Kármán's integral momentum principle to the case of laminar boundary-layer control by continuous suction through porous walls, and solves the general problem where the suction-velocity distribution is not prescribed but has to be calculated from the required behavior of the boundary layer. He shows first that the standard method has some shortcomings; for example, the velocity in the boundary layer becomes infinite for a defined value of the suction velocity depending on the degree of approximation, and for constant thickness of the boundary layer the flow separates independent of the suction intensity and possesses other physically improbable attributes.

It is shown that these erroneous results are due to the use of three or more boundary conditions at the edge of the boundary-layer potential flow intersurface and only one condition at the surface. Thus, author proposes a new method where he introduces the following boundary conditions: At the edge, the boundary-layer velocity input is equal to the potential velocity, and its derivative with respect to the normal direction is equal to zero. At the surface, the boundary-layer velocity either equals zero or has a slip given by the amount of suction, and the velocity is equal to the suction velocity v_0. The momentum equation and its first and higher derivatives with respect to the normal of the surface give additional conditions. If one makes the required calculation with these conditions, the coefficients of the approximation polynomial seem to be free of the restrictions of the standard method. Author gives a numerical example for the new method and determines the suction-velocity distribution over a wing which is necessary to maintain a laminar boundary layer of prescribed thickness.

K. Pohlhausen, USA

1980. Wilson, R. E., Turbulent boundary growth with favorable static pressure gradient at supersonic speeds, Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 277–288, 1952. $6.

A method is given for calculating the growth of turbulent boundary layer over a surface on which the static pressure gradient is favorable. It is assumed that the flow is compressible and

isentropic outside the boundary layer. At any cross section normal to the flow, the conditions on the thermally nonconducting surface are considered constant, and the boundary-layer thickness is of a uniform thickness which is small in comparison with a minimum flow cross-sectional diameter. The rate of change of the cross-sectional perimeter must be small. The velocity distribution in the boundary layer is assumed to be equal to that along a flat plate under similar flow conditions.

The calculations are used in particular for calculating the boundary-layer growth along the walls of a two-dimensional channel, such as a wind tunnel with a closed test section. Author has used his equations, together with previously gathered experimental data, to calculate the boundary-layer growth on two tunnels whose design Mach numbers are 2 and 5 and whose test section Reynolds numbers are 1×10^6 and 6×10^6. In the Mach number 2 tunnel, measurements are in good agreement with predicted values; at Mach number 5, the agreement, though reasonably good, indicates that the method is questionable beyond this range.

As the paper is chiefly of practical interest, its usefulness is somewhat reduced by the very condensed form in which it is presented. A minor error in the nomenclature and the small scale drawings also detract from its usability.

Ione D. V. Faro, USA

1981. **Cope, W. F., The measurement of skin friction in a turbulent boundary layer at a Mach number of 2.5, including the effect of a shock wave,** *Proc. roy. Soc. Lond.* (*A*) **215,** 1120, 84–99, Nov. 1952.

Author applied the old Stantan surface tube technique (1920) for measuring skin friction of low-speed boundary layer to the boundary layer along the side wall of an $M = 2.5$ nozzle. Taylor's calibration curve (1938) was directly used, although the original calibration was carried out for much lower velocities. The velocity gradient at the wall was determined by extrapolating the velocity profile very close to the wall, the claimed accuracy of the result being $\pm 7.5\%$. The local skin friction thus inferred was estimated to have an error of $\pm 9\%$, based upon the maximum scatter. Author then concludes that the surface tube is a reliable means of measuring skin friction, in spite of the large velocity gradient at the wall. Numerical results of the measured local skin-friction coefficient were shown to check satisfactorily with author's theory, yet to be published, regarding the effects of Reynolds and Mach numbers. Measurement was then made for the turbulent boundary layer with an oblique incident shock of strength 2. With the help of ordinary Pitot tube, details of the flow field (skin friction, Mach number, static pressure, Pitot pressure) near the intersection of the oblique shock and the boundary layer were explored and presented. The general phenomena agreed qualitatively with observations by previous investigators. Due to omission of humidity control in the nozzle flow, Dr. Wegener of the Naval Ordnance Laboratory pointed out to the reviewer that, quantitatively, the flow-field description for shock-boundary-layer interaction should be accepted with reservation.

Reviewer believes that the described technique is worthy of careful consideration by experimentalists in this field. Certainly it appears like a simple and effective way of measuring local skin friction near the separation point, where the momentum-thickness method is known to be inaccurate and direct-force measurement might also be impractical. S. F. Shen, USA

1982. **Sternberg, J., A free-flight investigation of the possibility of high Reynolds number supersonic laminar boundary layers,** *J. aero. Sci.* **19,** 11, 721–733, Nov. 1952.

Author describes experimental verification of Lee's prediction that, at supersonic speeds, large extents of laminar boundary-layer flow are possible due to the stabilizing effect of the heat transfer from air to surface, which increases the critical R_x and decreases the amplification rate of unstable oscillations.

Test area was the polished surface of a 20° included angle conical nose, replacing the standard V-2 warhead. During most of V-2 supersonic low-trajectory flight, the air-to-surface heat transfer was greater than required to damp oscillations according to theory. Cone angle of attack, surface irregularities, and skin heat conduction and radiation were assumed small enough as not to affect boundary-layer transition. By comparing measured and predicted surface-temperature rise and total pressure distribution, the laminar or turbulent state of the boundary layer was established.

The highest R_x on the cone, at which the boundary-layer flow was laminar, was 9×10^7 at Mach = 2.7, corresponding with an equivalent flat plate R_x of 5×10^7. Yap Kie Jan, Holland

1983. **Krzywoblocki, M. Z. V., On the equations of decay of isotropic turbulence in magneto-hydrodynamics,** *J. phys. Soc. Japan* **7,** 5, 511–512, Sept./Oct. 1952.

On the basis of his previous works, author derives the equations of the decay of isotropic turbulence in magneto-turbulence in compressible media. All the random variables fulfill the requirements of isotropy and homogeneity and are dependent. Author assumes that the reader is acquainted with previous papers on the subject. From author's summary by D. R. Chapman, USA

1984. **Tani, I., On the design of airfoils in which the transition of the boundary layer is delayed,** *NACA TM* 1351, 74 pp., Oct. 1952.

Translation from *Rep. aero. Res. Inst., Tokyo Univ.* **19,** 1, Jan. 1943.

1985. **Drake, R. M., Jr., Seban, R. A., Doughty, D. L., and Levy, S., Local heat transfer coefficients on the surface of an elliptical cylinder, axis ratio 1:3, in a high speed air stream,** ASME Ann. Meet., New York, Dec. 1952, Paper 52—A-59, 16 pp., 17 figs.

Heat-transfer and surface friction temperature were measured, mainly in order to check existing theoretical work for laminar flow. Heat was applied by passing electrical current through smooth Nichrome ribbons 0.002 in. thick and 1 in. wide, which were fixed on the cylinder surface. With this arrangement constant heat rate but variable wall temperature is obtained. Surface temperatures were measured by thermocouples mounted on undersurface of ribbon but electrically isolated from it. Elliptic cylinder had a major axis of 6 in. and was placed in a 6-in. by 9-in. test section of a wind tunnel. Range of experiments covers Reynolds number of 4.3×10^5 till 13×10^5, velocities 150 to 440 fps, and angle of incidence 0° and 6°. Surface friction temperature agrees well with theory. Rate of heat transfer also agrees well with a theory of E. Eckert [*VDI Forschungsheft* 416, 1942] modified for variable wall temperature by R. A. Seban [*Univ. Cal., Inst. Eng. Res. Rep.* 2–12, 1950] at stagnation point and its neighborhood; however, further downstream experimental values are larger by about 20% than those given by theory. Separation predicted by theory coincides with characteristic sharp change in heat-transfer curve. H. Schuh, Sweden

1986. **Chesterman, W. D., The dynamics of small transient cavities,** *Proc. phys. Soc. Lond.* (*B*) **65,** part 11, 395B, 846–858, Nov. 1952.

Cavitation bubbles are produced by abrupt deceleration of a vertically moving, liquid-filled glass tube closed at the bottom.

Growth and collapse of the bubbles are followed with the aid of high-speed motion pictures. Multiple oscillations are frequently observed. Graphs and tables of the life cycle of the bubbles are given. Measurements are presented for water and various water-acetone solutions. Carbon tetrachloride is reported "very difficult" to cavitate. Observations with a hydrophone show that the emission of sound coincides with collapse of the bubble.

Reviewer believes that, although many numbers are given, this research can hardly be considered more than very qualitative. The external pressure in the liquid is unknown during the life of the bubble. Many of the bubble diameters are a large fraction of the tube diameter. The attempted application of Rayleigh's formula for bubble collapse in an infinite medium is invalid under these conditions. Surface-tension effects, also discussed, can hardly be expected to show up in bubbles several millimeters in diameter, although they are important in bubble nuclei. The most significant result of this research, in reviewer's opinion, is the emitted sound pressure observations, which are mentioned only briefly. F. G. Blake, Jr., USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 1827, 1949, 1950, 1951, 1973, 1974)

1987. Shinbrot, M., An analysis of the errors in curve-fitting problems with an application to the calculation of stability parameters from flight data, *NACA TN* 2820, 29 pp., Nov. 1952.

A method is developed for assessing the errors in parameters obtained from a curve-fitting process. For linear curve-fitting problems, the resulting formula is closely related to the variance in probability theory. The method is applied to the problem of calculating stability parameters of an airplane, and the detailed calculations are given for an interesting example. This paper is an extension of previous work by the same author, reported in *NACA TN* 2622 [AMR **5**, Rev. 1923]. D. Young, USA

1988. Donegan, J. J., and Pearson, H. A., Matrix method of determining the longitudinal-stability coefficients and frequency response of an aircraft from transient flight data, *NACA Rep.* 1070, 11 pp., 1952.

See AMR **4**, Rev. 4252.

1989. Lichtenstein, J. H., and Williams, J. L., Effect of high-lift devices on the static-lateral-stability derivatives of a 45° sweptback wing of aspect ratio 4.0 and taper ratio 0.6 in combination with a body, *NACA TN* 2819, 50 pp., Nov. 1952.

Report contains results of wind-tunnel tests at $M = 0.16$, $Re = 0.89 \times 10^6$. Effects of leading-edge slats, split and plain flaps were investigated.

At moderate and high C_L, increasing flap span increases effective dihedral and directional stability. Slats tend to extend trends obtained at low C_L to higher C_L. Data reported include C_L, C_m, C_D, C_{y_β}, C_{n_β}, C_{l_β}.

An approximate theory is presented for estimating the increments in the lateral-static-stability derivatives due to flaps.

B. Etkin, Canada

1990. Bleviss, Z. O., Some roll characteristics of plane and cruciform delta ailerons and wings in supersonic flow, *Douglas Aircr. Co. Rep.* no. SM-13431, 84 pp., 1949.

The "missiles" considered here have symmetrically arranged forward fins of half-delta planform; there may be either two of these (plane arrangement) or four (cruciform). Wing-body interference is neglected; i.e., the body has negligible dimensions. The first investigation involves the rolling moment due to anti-symmetrical deflection of the two horizontal fins, in both the plane and cruciform arrangements. In the latter, there is an increase of rolling moment on the deflected fins, but a counter rolling moment is also induced on the vertical fins. A range of leading-edge sweepback angles (including both "subsonic" and "supersonic") and Mach numbers is covered; the sweepback angles of horizontal and vertical parts in the cruciform arrangement are not necessarily equal. The standard methods of linearized supersonic wing theory are employed. Next, the rolling moment due to combined yaw and pitch of both plane and cruciform configurations is calculated. Finally, the counter rolling moments induced on lifting surfaces well downstream of the fins are computed for several geometries. Here the induced velocities appropriate to the Trefftz plane are used, and any deflection or distortion of the trailing vortex sheets is ignored.

W. R. Sears, USA

1991. Rouanet, R., Contribution to the study of aircraft with deformable wings (in French), *Publ. sci. tech. Min. Air, Paris*, no. B.S.T. 114, 52 pp., 1951.

Solutions to the problem of building airplane wings which will reduce the effects of gust loads are divided by the author into five groups: (1) Deformation due to the elasticity of the wing itself; (2) deformation by automatic change of aileron angle; (3) deformation of articulated wings without elastic support; (4) deformation with elastic support but without change of angle of incidence; and (5) deformation with elastic support and change of angle of incidence. The author and the co-inventor Rey have analyzed the problem and believe they have a new solution falling in the last group.

After the liberation of France, two twin-motor monoplanes were built, one with fixed wings, and the other with its wings articulated in accordance with this new idea. Both articulated wings had horizontal hinges outside the engine nacelles inclined at 30° to the X-axis so that the angle of incidence would decrease as the wings rose under increased loads. Ailerons were eliminated and roll control was obtained by differential motion of the elevators. Oscillograms were taken of wing motion when flying at 200 mph in turbulent air and the results were "encouraging." Further plans include tests with a towed glider.

This solution would add weight to an airplane unless a considerably lower load factor could be justified for such a design of wing. Another probable disadvantage would be the change of airplane characteristics as wing load (and, hence, angle-of-wing incidence) changed in maneuvering. Changes of stall and spin characteristics at critical times could be very serious. The reviewer believes that a study of the natural gust alleviation provided by a helicopter rotor would be valuable in this connection. Great flexibility is commonly provided in helicopter blades, but flutter is avoided because of the forward location of blade cg and torsional center. Change of angle of attack with gust loads is provided, not by change of blade-pitch angle, but by the rising or falling speed of the helicopter blade after meeting a gust.

W. C. Johnson, Jr., USA

1992. Amick, J. L., Method of selecting the thickness, hollowness, and size of a supersonic wing for least drag and sufficient bending strength at specified flight conditions, *NACA TN* 2754, 38 pp., July 1952.

Author develops a quick and approximate method of obtaining an optimum wing for application to a supersonic airplane or missile. It is assumed that planform, section shape, and lift requirement of the wing are specified, and that bending stress is carried entirely by the skin. Neglecting the fuselage lift, it is shown that

the method reduces to a rather straightforward optimizing procedure. In an example application, a diamond wing at Mach number 2 is treated for a range of flight conditions. Author finds that at low altitudes steel wings are superior to aluminum wings, while at high altitudes the reverse is true. It is also concluded that wings appreciably different from the optimums may have considerably higher drags. This appears especially to be the case for high-altitude flight. From an approximate form of the general method, it is deduced that, at high supersonic speeds, wings should have zero taper ratio and small aspect ratio for least drag.

Reviewer believes the proposed method may prove useful; however, the assumption that fuselage lift may be neglected by comparison to wing lift would appear to be rather restrictive, especially in the case of missiles. A. J. Eggers, Jr., USA

1993. **Bleakney, W. M., and Morikawa, G. K., Reciprocity relations in wing-body systems,** *J. aero. Sci.* **19,** 11, 784–785, Nov. 1952.

Note in Readers' Forum.

1994. **Pasqualini, C., Use of Germain operators for the solution of the linear wing equation** (in Spanish), *Univ. nac. La Plata, Publ. Fac. Cienc. Fisicomat.* (2) **4,** 4, 352–355, Dec. 1951.

This paper deals with the solution of the integral equation defining the distribution of lift on a finite wing. The method is based on the properties of Germain's operators [P. Germain, "Sur le calcul numérique de certains opérateurs linéaires," *C.R. Acad. Sci.*, p. 765, 1945].

Using the substitution $\vartheta = \arccos(2y/b)$, the span is divided into n equal angular intervals $\Delta\vartheta$. Exact values of the circulation function $\Gamma(y)$ are obtained by solving a system of $n - 1$ linear equations in the most general case. It reduces to $n/2$ equations in the symmetric case and to $-n/2 - 1$ equations in the antisymmetric case. Reviewer believes that Pasqualini's method is of considerable interest for applications. A. Miele, USA

1995. **D'Attorre, L., Determination of the lift distribution in wings having finite span by Pasqualini's method** (in Spanish), *Univ. nac. La Plata, Publ. Fac. Cienc. Fisicomat.* no. 28, Feb. 1951.

Paper deals with the practical application of Pasqualini's method regarding the distribution of lift on wings having finite span. Both the symmetric and the antisymmetric cases are considered. A matrix solution is also given. Numerical examples emphasize the engineering importance and the remarkable rapidity of the method. [See preceding review.] A. Miele, USA

1996. **Smith, G. W., and Rea, J. B., Aeroplane tail loads for longitudinal manoeuvres,** *J. roy. aero. Soc.* **56,** 502, 789–800, Oct. 1952.

Method for calculating tail loads, using standard IBM computing machinery is outlined. Main advantages are the time saving and convenience in handling arbitrary elevator inputs. Method applies to any dynamical system whose physical characteristics can be expressed as linear differential equations with constant coefficients. H. Lomax, USA

1997. **Van Spiegel, E., An approximate theory of the oscillating wing with control surface in a compressible subsonic flow for low frequencies,** *Nat. LuchtLab. Amsterdam Rap.* F.114, 15 pp., 1 table, 5 figs., 1952.

An approximate theory is developed for a thin two-dimensional airfoil with control surface oscillating with low frequencies in a compressible subsonic flow. The approximation is obtained by neglecting the wave term in the differential equation determining the velocity potential. In this report, only the first approximation is derived. From author's summary by R. Simon, USA

1998. **Kemp, N. H., On the lift and circulation of airfoils in some unsteady-flow problems,** *J. aero. Sci.* **19,** 10, 713–714, Oct. 1952.

Author enumerates, for application in a future paper, some results of the two-dimensional incompressible unsteady-lift theory which follow more or less directly from the well-known work of von Kármán and Sears. These include expressions for: (1) The total circulation about an oscillating airfoil; the potential jump in the wake of such an airfoil. (2) The lift on an airfoil in a sinusoidal gust advancing on the airfoil with the free-stream velocity. (3) A generalized expression for the list and circulation about an airfoil in a sinusoidal gust that is advancing at an arbitrary velocity.

It is shown that both (1) and (2) are proportional to a frequency response function $S(\omega) = [1/(i\omega)][K_0(i\omega) + K_1(i\omega)]$ (where K_0 and K_1 are Bessel functions), for which a table of values is given. The generalized expression (3) is interesting in that it contains, as special cases, the Theodorsen function for an oscillating airfoil and the Sears function for a sinusoidal gust.

Reviewer believes that a minor slip is made in the description of the relationship between a step-input response and the frequency response. The step-input response is multiplied, not divided, by the transform variable in the process of conversion to frequency response. Reviewer notes that the expression given for (2) can be obtained by this process directly from the result of Sears for the sharp-edge gust if a factor is included to account for the shift in phase due to the shift in origin, which, for the sharp-edged gust, is taken at the leading edge but, for the sinusoidal gust, is taken at the center. Likewise, the expression for (3) can be obtained from the response for a sharp-edged gust advancing at an arbitrary velocity, but, in this case, the method which the author uses (based upon Sears' method of expansion in Fourier series) is simpler. L. Pode, USA

1999. **Monaghan, R. J., A theoretical examination of the effect of deadrise on wetted area and associated mass in seaplane-water impacts,** *Aero. Res. Counc. Lond. Rep. Mem.* 2681, 16 pp., Mar. 1949, published 1952.

The two-dimensional impact case for vertical drop of a wedge at zero attitude is examined. New theoretical formula is developed by means of expanding prism flow giving results for associated mass in close agreement with those given by Wagner's semi-empirical formula. Treatment also gives a formula for wetted area which is only available from Wagner's treatment for very small values of dead-rise angle. Comparison is made between these and other formulas in the light of theory and experiment, and a brief survey is made of the assumptions involved in applying associated mass methods to motions through a free surface.

From author's summary by A. F. W. Langford, Australia

2000. **Miller, R. W., Theoretical analysis of hydrodynamic impact of a prismatic float having freedom in trim,** *NACA TN* 2698, 31 pp., June 1952.

Author applies previously derived hydrodynamic theory [AMR **1,** Rev. 709] to motion of a V-bottom float with a transverse step when pitching motion is permitted in addition to translatory motions. Results, obtained by numerical integration of two simultaneous nonlinear differential equations, are compared to solutions obtained when pitching is not permitted, as well as to author's experimental results [*NACA TN* 1776, 1948]. Although mathematical model had an infinitely wide V-bottom, while the experimental models had pointed steps, flared chines, and after-

bodies, the trends of the results agree, particularly during the initial stages of the impacts. Calculations are carried out for three sets of initial conditions; time histories of displacements, velocities, and accelerations are presented graphically for the pitch and no-pitch cases. Experimental results are presented on separate graphs, making comparisons awkward, especially where it appears that typographical errors occur in the time scales. [See discussion in AMR **3**, Rev. 1314 for remarks by Miles which are also pertinent to the report under review.]

T. F. O'Brien, USA

2001. Inoue, E., Interrelations between the structure of wind near the ground and its observations, *J. meteor. Soc. Japan* **30,** 8, 255–264, Aug. 1952.

Statistical quantities in the wind near the ground are modified by observational procedures and the sensitivit of instruments. The latter produce *subjective* changes in the statistical quantities observed. Since some *objective* characteristic quantities of the wind depend on its mean velocity, wind observations cannot be properly interpreted unless both subjective and objective changes in structure are considered. This paper aims to clarify agreements and disagreements between theoretically calculated results and observed quantities.

Author studies some theoretical characteristics of turbulent flow by means of a model. After considering how the method of observation and the sensitivity of instruments modify theoretically derived quantities, he compares them with actual wind observations.

Reviewer believes that value of this paper lies in its emphasis on subjectivity of observational instruments and procedures, and the necessity to understand the manner in which observations distort objective wind properties before the latter can be fully understood.

H. Riehl, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 1791)

2002. Bergh, H., Experimental determination of the aerodynamic coefficients of an oscillating wing in incompressible, two-dimensional flow. Part III. Experiments at zero airspeed, *Nat. LuchtLab. Amsterdam Rap.* F.103, 6 pp., 2 tables, 1952.

In order to proceed with the calculation of the coefficients of the aerodynamic forces and moments of the oscillating wing, it was necessary to reduce the results of the experiments of parts I and II to the same reference (i.e., either still air or vacuum). For this purpose, the moments were measured in still air and this value could then be used to correct the data for the effect of the air. Part III presents the results of these experiments, and the values of the coefficients are given in tabular form.

M. Alperin, USA

2003. Bergh, H., and van de Vooren, A. I., Experimental determination of the aerodynamic coefficients of an oscillating wing in incompressible, two-dimensional flow. Part IV. Calculation of the coefficients, *Nat. LuchtLab. Amsterdam Rap.* F.104, 17 pp., 6 tables, 13 figs., 1952.

The aerodynamic force and moment coefficients of a sinusoidally oscillating wing are calculated from measurements presented in parts I, II, and III. The coefficients are given for values of the reduced frequency varying from 0.08 to 1.0.

Results at the lower values of the reduced frequency are in excellent agreement with the theory, but at higher values of reduced frequency there exists a systematic deviation between theory and experiment.

The internal experimental error is very small and calculation of the coefficients by different methods presents results in good agreement with each other.

M. Alperin, USA

2004. Lawrence, H. R., and Gerber, E. H., The aerodynamic forces on low aspect ratio wings oscillating in an incompressible flow, *J. aero. Sci.* **19,** 11, 769–781, Nov. 1952.

See AMR **6**, Rev. 534.

2005. Gongwer, C. A., A study of vanes singing in water, Nat. Conf. ASME, State College, Pa., June 1952, Paper 52-APM-33, 7 pp.

In the course of propulsion experiments, it was discovered that certain struts which are used to support underwater bodies would "sing" at surprisingly low speeds, e.g., 5 to 7 knots. Tail surfaces also sang. The note emitted was a clear musical tone in most instances, and, as the speed was increased, the note would fade, disappear, and then reappear as a note of higher frequency. Analysis for flutter stability and torsional divergence had been conducted, and it was known that the operation was well away from the ranges where flutter or torsional divergence might occur. However, the severity of the singing did not tend to become greater at high speeds, and there were usually quiet speed zones at high speeds as well as at low speeds.

From author's summary

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 1802, 1936, 1944, 2035, 2039, 2041, 2095)

2006. Lerbs, H. W., Moderately loaded propellers with a finite number of blades and an arbitrary distribution of circulation, *Soc. nav. Arch. mar. Engrs.*, 45 pp., Nov. 1952.

Paper is a long and detailed exposition of classical propeller theory, replete with curves and diagrams. The general theory of the propeller is based on vortex theory; in particular, the flow field due to helical vortexes is found. The influence of a hub cylinder on this flow field is then found, etc.

Applications of the theory are then made to the following cases: Free-running propellers: moderately loaded, and then optimization problems, effect of finite hub diameter, and nonoptimum propellers. The theory of wake-adapted propellers is then developed, and applications to the optimum and nonoptimum wake-adapted propellers are made. Appendixes treat the calculation of velocity potential and velocity components of helical vortex lines.

The paper is comprehensive and well written and should be very rewarding to specialists in this field, if the limitation to potential flows is borne in mind.

B. W. Augenstein, USA

2007. Mortarino, C., Experiments on blade cascades for turbines (in Italian), *Politecn. Torino, Lab. Aero. Monogr.* no. 290, 22 pp., May 1952 = *Aerotecnica* **32,** 4, 192–205, Aug. 1952.

Author reports experiments he performed on an NACA 6512 airfoil blade cascade having a gap/cord ratio of 0.7 and so arranged to determine the fluid expansion; angle between cascade axis and normal to airfoil reference chord was $\beta = -46°.6$; Reynolds number was 400,000, Mach number 0.17. Results are obtained by means of pressure measurements at blade surface and of fluid flow surveys ahead and behind cascade.

Flow on blade surface has been visualized (by an original method of author) to show the influences of the boundary layers at blade and tunnel wall surfaces. A great number of diagrams are presented; in particular, lift and drag coefficients and turning

angles determined by cascade. Experimental results are compared with values calculated by the Ferrari formulas.

Tests are performed and critically analyzed, and a valuable contribution is made to cascade-performance knowledge and to inherent experimental technique. C. Ferrari, Italy

2008. **Meyer, R. E., The mean flow in Kaplan turbines,** *Trans. ASME* **74, 7,** 1283–1289, Oct. 1952.

After reviewing the principles of the Euler mean-flow theory for turbomachines, together with its more recent two- and three-dimensional modifications which have proved of great value in the design of axial-flow machines, author considers one by one the correction terms required to account for the principal deviations from the usual assumptions of concentric cylindrical flow without trailing vortexes. In particular, consideration is given to the modifications due to (a) ring vorticity, (b) nonuniform approach flow, (c) changes in gate opening and blade angle. Practical solution techniques are indicated to obtain approximate correction terms, which the author states may be simply superposed to obtain estimated combined effects. Appendixes include mathematical details, together with remarks on limitations of the Euler theory and the modification techniques.

H. M. Paynter, USA

2009. **English, R. E., and Cavicchi, R. H., One-dimensional analysis of choked-flow turbines,** *NACA TN* 2810, 53 pp., Oct. 1952.

Turbines requiring high work output per stage can easily have one or more blade rows which are choked for at least part of the operating range. Choking is defined in a turbine by constant equivalent weight flow with an increase in turbine pressure ratio at constant equivalent blade speed. If the pressure ratio is increased above the choking value, flow conditions upstream of the choked throat are independent of pressure ratio and dependent only on turbine geometry.

The choking flow is investigated by means of a one-dimensional analysis based on isentropic flow. The analysis indicates that area ratios, blade speed, and blade-row exit-flow angles are the controlling factors for the design and operation of such turbines. An increase in equivalent blade speed for a given turbine makes the internal flow conditions less critical for most applications. The analysis indicates that manufacturing errors in area ratio do not affect flow conditions for choked-flow turbines to a great extent. Criteria are stated to determine from turbine test data the blade rows in which choking occurs. H. E. Sheets, USA

2010. **Erni, E., An experimental installation for the testing of compressor stages,** *Brown Boveri Rev.* **39,** 5/6, 169–174, May/June 1952.

At the peripheral speeds of 250 to 300 m/s normally prevailing in modern air compressors, the compressibility of the air becomes noticeable. The experimental installation described was, therefore, built to investigate this effect on the behavior of the impeller. Since the sonic velocity is of the order of 340 m/s in air, but only about 140 m/s in CClF, it was decided to employ this heavy gas as the working fluid. As a result, it was possible to attain high Mach numbers at peripheral speeds which would allow the use of impellers that could be easily and rapidly cast in light metals. From author's summary by W. T. Olson, USA

2011. **Lalive d'Epinay, J., Theoretical and experimental research in the field of centrifugal and axial-flow compressors,** *Brown Boveri Rev.* **39,** 5/6, 161–168, May/June 1952.

After Brown Boveri had been engaged for several decades in the development of centrifugal and axial-flow compressors, an extensive investigation was begun in 1942 to check and widen existing knowledge. New improved forms were developed and new blading planned and tested. Several of the fundamental deliberations and conclusions of the long years of research activity are reproduced here. As the axial-flow compressor was the subject of an earlier report, the centrifugal compressor is treated in greater detail in this article. The chief emphasis is laid on the method of investigation, experimental results being added as examples. From author's summary

2012. **Wosika, L. R., Radial-flow compressors and turbines for the simple small gas turbine,** *Trans. ASME* **74,** 8, 1337–1347, Nov. 1952.

Paper describes the procedure followed in developing an acceptable radial-flow turbine for use with a lightweight gas-turbine-driven fire pump for the Navy Bureau of Ships. In the course of this work, considerable data were accumulated on general design information and practice on radial compressors and turbines. A review is given of these data as well as the current design approach for a simple cycle radial-flow gas turbine. A discussion of the factors and variables which affect the performance of radial turbomachines is included.

From author's summary

2013. **London, A. L., and Kays, W. M., Liquid-coupled regenerators for turboprops,** *Aero. Engng. Rev.* **11,** 10, 42–53, 124, Oct. 1952.

An engineering study of the use of a regenerative cycle for a turboprop engine wherein liquid metals are used to convey energy from an exhaust heat exchanger to a heat exchanger after the compressor. M. Tribus, USA

2014. **Agneluzzi, L., Determination of the elastic line of airscrew blades** (in Italian), *Riv. aero.* **28,** 7, 547–551, July 1952.

It is well known that bending stresses in airscrew blades have two causes: air loads, and centrifugal load. Since the elastic deformation itself is an essential part of the lever arm of the latter, the integration of the two coupled differential equations of the problem is rather complicated. Author gives the necessary equations and discusses the possibility of solving them by iteration. It must, however, be mentioned that from Eq. (10) his relations are dubious, for this equation can be derived from Eq. (9) only in the (practically insignificant) case of the untwisted screw-blade (β_e = const), while author uses it without this restriction. K. Marguerre, Germany

2015. **Goldstein, A. W., Axisymmetric supersonic flow in rotating impellers,** *NACA Rep.* 1083, 14 pp., 1952.

Supersedes article reviewed in AMR **4,** Rev. 4515.

2016. **London, A. L., and Oppenheim, A. K., The free-piston engine development—present status and design aspects,** *Trans. ASME* **74,** 8, 1349–1360, Nov. 1952.

Three applications of free-piston engines are considered: (a) An internal-combustion-engine air-compressor combination where the useful output is compresed air for pneumatic purposes. (b) An air-compressor combustion-chamber combination for the production of hot gases under pressure for use in a turbine to produce shaft work. (c) The compressor system as described in (a), together with a combustion chamber for internal-combustion heating of the compressed air and then a turbine to utilize the hot gases for the production of shaft work. Performance data for several existing free-piston systems are presented, together with the results of cycle studies. The thermodynamic-dynamic

design aspects are considered relative to the conventional crank-type reciprocating internal-combustion-engine system. The general conclusion reached is that the free-piston system has the prime advantages of excellent thermodynamic performance combined with mechanical simplicity. Consequently, a major development effort appears to be well warranted.

From authors' summary

2017. Seddon, J., Air intakes for aircraft gas turbines, *J. roy. aero. Soc.* **56,** 502, 747–773, Oct. 1952.

"Intake design in the average case has come to involve the striking of a difficult and many-sided compromise." This extract is key to author's presentation, which aims at supplying sufficient information for a designer to make those compromises.

Paper divides intake problem into internal and external flows. Former deals with pressure recovery and stability and distribution of flow, while latter includes profile and bypass drag and compressibility effects.

Author derives general equation for intake loss which illustrates the importance of "position ratio," or ratio of wetted area ahead of intake to entry area. Deductions are confirmed by experiment, which show 10% loss ram efficiency for an increase of 13 in position ratio. Artificially, the position ratio can be decreased by boundary-layer bleed at the expense of external drag. In addition to position-ratio loss, those due to discharge into plenum chamber, blade-root drag in propeller turbine installation, and lip losses during ground running are also mentioned.

Instability in twin duct entries is discussed, and it is shown that decreasing either the position ratio or duct diffusion will reduce critical flow. Effect of entry on external drag is illustrated by three installations—wing leading edge, fuselage side, and NACA submerged intake. Cowl design itself is considered in relation to critical Mach number, and the NACA 1 series or quarter-ellipse profiles are considered satisfactory.

F. G. Blight, Australia

2018. Zucrow, M. J., and Beighley, C. M., Experimental performance of WFNA-JP-3 rocket motors at different combustion pressures, *J. Amer. Rocket Soc.* **22,** 6, 323–330, Nov.-Dec. 1952.

The performance and heat-transfer rates for 500-lb thrust, $L^* = 100$ in. rocket motors were determined experimentally as a function of mixture ratio at 300, 500, and 700-psia combustion pressures. In all cases, the propellants were white fuming nitric acid (WFNA) and jet engine fuel (JP-3). The maximum values of specific impulse were obtained at a mixture ratio of 4.5 and the values were 222, 235, and 246 for 300, 500, and 700-psia combustion pressure, respectively. Raising the combustion pressure from 300 psia to 700 psia increased the over-all heat transfer for the thrust cylinder from 1.3 to 2.3 Btu per sq in. per sec, and that for the nozzle from 2.8 to 6.0 Btu per sq in. per sec.

From authors' summary

2019. Mahrous, M. A., The development of a multi-flash camera and its application to the study of liquid jets, *Brit. J. appl. Phys.* **3,** 10, 329–331, Oct. 1952.

An apparatus to operate a microflash tube a number of times in rapid succession is described and applied to obtain cinematograph pictures of a water jet at a number of stations along its length. As the speed of efflux is increased, three stages in the form of the jet may be discerned in which (1) the jet becomes varicose, (2) it becomes sinuous, and (3) pieces are sheared off the sides by friction with the air. It appears that, below speeds of the order 20 m/sec, the liquid always breaks into pieces of a size comparable with the width of the jet. Subsequent breakup of individual drops into smaller units occurs owing to their high speed through the air.

From author's summary

2020. Hottel, H. C., and Hawthorne, W. R., Diffusion in laminar flame jets, Third Symp. Comb. Flame Expl. Phenom., Baltimore, Md., Williams & Wilkins, 254–266, 1949. $13.50.

The lengths and concentration patterns of flames from circular nozzles burning in free air are determined over a range of nozzle velocities with several nozzle diameters and for various gases and primary air-gas ratios. As the velocity is increased from zero, the flame, burning under conditions of diffusional mixing with air, increases in length until a transition occurs to turbulent combustion with a consequent change in flame length to a value which is substantially independent of further increase in velocity.

Paper covers that portion of the data related to laminar jets and to transition phenomena. The progress of combustion is treated analytically, assuming that molecular diffusion is controlling and that the concentration of oxygen and fuel are zero at the flame interface. A relation between the time of flow of fuel gas from the nozzle to the flame tip and the proportion of nozzle fluid and air required for complete combustion is obtained. It is found that, for short flames, the time of flow is proportional to flame length; for longer flames, the generalized flow time for a given nozzle fluid should be a function of the ratio of flame length to nozzle diameter, volumetric flow rate, diffusivity, and the Grashof number which enters wherever the major force overcoming viscous drag is one of buoyancy. The actual relationship is established empirically from data on flames of carbon monoxide and of city gas.

Data on phenomena of transition from laminar to turbulent flow in the flame jet are also presented.

From authors' summary by S. Ostrach, USA

Flow and Flight Test Techniques

(See also Rev. 1975)

2021. Bradfield, G., Precise measurement of velocity and attenuation of ultrasonic waves, *Atti Conv. Internaz. Ultracust.* **1950,** 162–181, 1951.

This paper reviews methods for measuring attenuation and velocity in solids and liquids. For liquids, all measurements are made by diffracted waves, i.e., by means of radiating and receiving devices which are several wave lengths in aperture so that diffraction effects confine the radiation to a beam of small divergence. In solids, guided waves, which occur when waves are transmitted in bars or strips, are also used, particularly at low frequencies. The paper discusses the refinements that must be applied to insure that these measurements give accurate results, and concludes that velocities are measurable to 1 part in 2000, while attenuation measurements of 1 part in 100 are attainable.

W. P. Mason, USA

2022. Fossa, D., Geometric representation of plane Laplacian fields by methods of Hele-Shaw and Lehmann (in Italian), *Energia elett.* **29,** 10, 650–657, Oct. 1952.

An introduction to fundamental laws of vectorial fields, in particular irrotational, is given first. Author then explains the by-eye method of flow net construction, which he attributes to Lehmann; reviewer points out that other authors assign paternity of this method to Forchheimer. Author reviews briefly the theoretical fundamentals of the Hele-Shaw device, based on Navier-Stokes equations. After describing a vertical Hele-Shaw apparatus, he describes his own experiments. The originality of his work, he claims, consists in using a horizontal marble plate on

which is placed an 0.8-cm thick glass plate. On this plate, a paper foil is glued. A piece of pasteboard of the shape of the boundary of the model is then glued to the paper foil. Small pieces of blue dye are added to obtain colored filaments. A second glass plate covers the apparatus, being separated from the first by the pasteboard model. Some good photographs of models are reproduced.

Author claims that he is aware that the Hele-Shaw method has not been used much to study practical problems. Reviewer thinks, however, that since 1898 (when the Hele-Shaw method was first published) many applications have been made. Among others, he recalls particularly the ones of Rouse ["Elementary mechanics of fluids," Wiley, 1947, p. 14, whose plate II is identical to fig. 14 of Fossa's experiment], Hinderks [*Cienc. y. Técn.* **102,** 500, Feb. 1944], Escande, Macagno [*ibid.*, **114,** 576, 1950, with quantitative applications] and those of reviewer [AMR **4,** Rev. 747, quantitative applications and use of boundaries of paraffined cartor.].

Reviewer thinks that the technique used by author is very accurate and permits a high degree of precision compatible with the method. However, he believes that possibly other procedures, particularly Southwell's numerical method, are preferred at present because of their greater accuracy.

A. Balloffet, Argentina

2023. **Carlson, R. W., and Pirtz, D., Development of a device for the direct measurement of compressive stress,** *J. Amer. Concr. Inst.* **24,** 3, 201–215, Nov. 1952.

Paper describes the development, analysis, and testing of a device called a "stress meter" which measures compressive stress in concrete more or less directly. It shows that it is possible to make an embedded device which at all times registers very nearly the same stress as the surrounding concrete, regardless of the deformations. It reports tests wherein stress meters embedded in a concrete specimen were shown to be practically insensitive to creep under sustained load and to maintain the same zero-stress reading when the specimen was subjected to a variety of conditions. The stress meters also indicate very nearly the correct stress when loaded at various ages, although the modulus of elasticity of the concrete changes markedly.

From authors' summary

2024. **Veret, C., Stereoscopic schlieren photography** (in French), *Rech. aéro.* no. 29, 3–7, Sept./Oct. 1952.

Apparatus described utilizes two beams transluminating flow field at a small inclination to each other; by the use of mirrors they are guided over the same schlieren edge and thence into the two objectives of the stereoscopic camera. Records obtained permit location of generally skew curve along which transluminating rays graze curved shock surfaces in three-dimensional flow fields. Examples of flows around a fork with two tines and around a missile with fins are given. F. J. Weyl, USA

2025. **Liepmann, H. W., Deflection and diffusion of a light ray passing through a boundary layer,** *Douglas Aircr. Co., Rep.* SM-14397, 13 pp., May 1952.

Total angle of deflection of light ray reaching wall through boundary layer, computed from Snell's law, is expressed in terms of main stream quantities and recovery factor of gas in boundary-layer flow.

Mean square deflection of normally incident light ray, having therefore mean deflection zero, is computed to within lowest-order terms of fluctuation in density gradient for turbulent boundary layer. Cross correlation in time of density gradients at two different points of light path is replaced under suitable homogeneity assumptions by space correlation along this path. Numerical estimates are made by relating fluctuations in density gradient to those of density and, finally, to those of turbulent velocities which for other than extremely high-speed flows are taken to have same order of magnitude as in low-speed flow. Reynolds number dependence is estimated for Prandtl number 1 with the result that, e.g., for free-stream Mach number 2 and Reynolds number 107, the root mean square deflection is 4×10^{-4} radius. F. J. Weyl, USA

2026. **Katz, I., A momentum disdrometer for measuring raindrop size from aircraft,** *Bull. Amer. meteor. Soc.* **33,** 9, 365–368, Nov. 1952.

There exists a need to measure raindrop distributions in storms being investigated by radar. A new airborne instrument for such measurements has been developed which measures simultaneously the droplet size and the total liquid water. It is primarily a capillary collector, inside of which is mounted a condenser microphone to measure the acoustic wave generated by the transfer of energy from the raindrop to the pickup. This device contains a "built-in" calibration system as it measures both the mass (by measuring momentum) and total volume of identical droplets.

From author's summary

2027. **Willmarth, W. W., and Nagamatsu, H. T., The condensation of nitrogen in a hypersonic nozzle,** *J. appl. Phys.* **23,** 10, 1089–1095, Oct. 1952.

Nitrogen used was commercial grade, 99.8% pure, with 0.1% each of oxygen and argon. Experiments were made in a small two-dimensional source-flow nozzle. Onset of condensation was found by light-scattering technique and by measurement of impact and static pressures. Results showed that, with stagnation conditions of about 70 F and 8 to 16 atm, the Mach number at which condensation occurred was about 1.2 greater than theoretical value for no supersaturation. Addition of small amount of carbon dioxide caused large reduction in amount of supersaturation. W. A. Mair, England

2028. **Laurence, J. C., and Landes, L. G., Auxiliary equipment and techniques for adapting the constant-temperature hot-wire anemometer to specific problems in air-flow measurements,** *NACA TN* 2843, 77 pp., Nov. 1952.

The constant-temperature, negative feedback-type hot-wire anemometer has been extensively discussed before, but relatively few accounts are available of its actual use in fluid mechanics research. Author gives detailed electronic circuit and operational procedures, including calibration for the use of a constant-temperature equipment, with the principal aim being the measurement of periodic flow fields in rotating machinery.

L. S. G. Kovasznay, USA

2029. **Baird, R. C., and Bechtold, I. C., The dynamics of pulsative flow through sharp-edged restrictions with special reference to orifice-metering,** *Trans. ASME* **74,** 8, 1381–1387, Nov. 1952.

Authors present simplified review of Bernoulli relationships as applied to fluid-flow measurement, pointing out that Bernoulli's theorem does not hold for pulsative-flow measurement, using inferential head meters.

Two theories are presented: (1) Pulse phase shift; (2) reflection. These theories are used in an attempt to explain the errors and phase shift observed across orifice plates.

According to authors, paper has two objectives: (1) To show in some detail how rapidly changing pressure conditions can and do require rather drastic modification of the equations usually employed to compute orifice pressure drop-flow relationships.

(2) To introduce electrical analogies into the orifice-metering problem, coupled with samples of field and laboratory experimental data with the suggestion that the concept of analogies be used to help analyze the orifice-metering problem as caused by pulsative flow.

Reviewer believes authors will find their two theories basically one and the same, namely, impedance. Also, paper's first objective can be reached only by implication from authors' dissertation. Regarding second objective, the experimental data presented show the phase-shift phenomena, but reviewer believes suggestion for application of electrical analogies should be used with discretion and only with reference to the differential equations involved. C. Newman, USA

2030. Johannesen, N. H., and Mair, W. A., Experiments with large pitot tubes in a narrow supersonic wake, *J. aero. Sci.* **19,** 11, 785–787, Nov. 1952.

Experiments were carried out by authors to investigate the effect of the finite size of a Pitot tube when used to measure total pressures in a narrow supersonic wake. The measurements were carried out at a free-stream Mach number of 1.96; a 20° wedge produced the wake. Results showed that, for outside Pitot diameters up to four times the wake width, no significant variation was found. For larger outside diameters, the internal tube diameter was found to be of major importance. The ratio of outside to inside diameter had no significant effect for the small size Pitot tubes. R. A. Gross, USA

2031. Krzywoblocki, M. Z., Remarks on "Analytical approach to the fuel sloshing and buffeting problems of aircraft," *J. aero. Sci.* **19,** 10, 715–716, Oct. 1952.

Note in Readers' Forum.

Thermodynamics

(See also Revs. 1913, 1955, 2013, 2016, 2018, 2068, 2069)

2032. Tanishita, I., New equation of state for air valid to 1000 atm (in Japanese), *Trans. Soc. mech. Engrs. Japan* **17,** 62, 64–70, Nov. 1951.

Author proposes a new equation of state of air in the form $v = f(p, T)$, based on the experimental results of Amagat and Witkowski. This equation is valid up to 1000 atm above 0 C, to 120 atm above −35 C, to 80 atm above −80 C, and to 40 atm above −100 C. Specific heat and Joule-Thomson effect calculated from this equation are compared with experimental data. Temperature-entropy and enthalpy-entropy diagrams are presented. H. Tamaki, Japan

2033. Tolhoek, H. A., and De Groot, S. R., A discussion of the first law of thermodynamics for open systems, *Physica* **18,** 10, 780–790, Oct. 1952.

For a closed system which cannot exchange matter with the surroundings, the first law of thermodynamics is given by

$$dU = dQ - pdV \qquad [1]$$

where dU is the change in energy, dQ the heat supplied to, and p the pressure exerted on the system; V is its volume.

If the system exchanges matter with its surroundings, as happens in many cases of the thermodynamics of irreversible processes, e.g., diffusion, [1] has to be replaced by

$$dU = dQ - pdV + hdM \qquad [2]$$

where h is the enthalpy per unit mass, and M the mass. If the mass flow is connected with special heat effects, as the Dufour effect in diffusion, dQ cannot be measured directly. In this case, [2] is not simply a generalization of [1], but partly a definition. The consequences of this fact are discussed and the fundamental laws for irreversible thermodynamics are written in a form consistent with these considerations. L. Meyer, USA

2034. Hirschfelder, J. O., Curtiss, C. F., and Campbell, D. E., The theory of flame propagation IV, University of Wisconsin, Report CM 756, Nov. 24, 1952.

The set of general equations describing steady, one-dimensional, and laminar flame propagation has been applied to three specific systems, viz., (1) the unimolecular decomposition of hydrazine, (2) the bimolecular reversible decomposition of nitric oxide, and (3) the decomposition of ozone. Because of the lack of adequate data on the detailed chemical kinetics of the reactions, drastic simplifications and assumptions must be made in order to obtain tractable problems. For example, for the decomposition of hydrazine, authors state the well-known result that the "decomposition is clearly a complicated chain reaction," and yet are forced to assume that the rate of the over-all reaction is controlled by the process $N_2H_4 \rightarrow 2NH_2$, for which rate data are available. Similarly, there is considerable experimental evidence in support of the idea that the decomposition of NO is not a single-step bimolecular reaction, as assumed by the authors. In the case of the ozone flame, the same kinetics data as were used by Lewis and von Elbe in 1934 have been employed in connection with the more complete theoretical analysis developed by Hirschfelder and his collaborators.

Considering the uncertainties in our detailed knowledge of the chemical reaction rates, reviewer is somewhat amazed at the close agreement between calculated and observed burning velocities for ozone (calculated value of linear burning velocity = 55 cm/sec, experimental value = 47 cm/sec) and for hydrazine (calculated value = 200 cm/sec, observed value = 127 cm/sec). At least for hydrazine and nitric oxide, the calculations require essentially an intelligent guess as to what is a reasonable rate-controlling reaction step for a complicated process. It is gratifying to note that the authors do not hesitate to make calculations for the decomposition flame of NO for which experimental data will soon be forthcoming.

Although one may argue that the type of numerical calculations carried out by Hirschfelder and his collaborators is not warranted because of major uncertainties in the required physicochemical constants, it can hardly be denied that the results constitute a significant contribution to our understanding of laminar flame propagation. For example, the present analysis contains the first quantitative demonstration that the normal reaction scheme for ozone decomposition demands a concentration of oxygen atoms, just ahead of the hot boundary, which is many orders of magnitude greater than the thermodynamic equilibrium value. Results of this sort have been suggested previously on the basis of spectroscopic studies of flames. S. S. Penner, USA

2035. Lichty, L. C., Evaluation of flame speed at burner flame tip, *Indust. Engng. Chem.* **44,** 6, 1395–1398, June 1952.

If flame velocity at the tip of a Bunsen burner is computed on the assumptions that the flow lines of unburned mixture here enter the flame surface perpendicularly without change of direction, and that the flame velocity at the tip is equal to the velocity of the unburned central lamina mixture as it leaves the burner tube, then a very high flame velocity at the flame tip results [Lewis, B., and von Elbe, G., "Combustion, flames, and explosions of gases," pp. 238–241, New York, Academic Press, 1951]. The problem is that this velocity may calculate to be more than

three times the velocity found only 0.02 cm away from the burner axis; the problem is a basic detail in the use of the Bunsen burner for flame speeds. A different way to evaluate flame speed at a flame tip is described by Lichty and results in much lower values. He proposes that, as the central mixture stream approaches the tip, it is slowed by ramming from original stream velocity, V_1, to V_2. It is then heated by the flame, and, in passing through the flame, has its velocity increased by the usual momentum effect from V_2 to V_3, which is equal to the original stream velocity V_1. Author holds that V_2 is the flame velocity, as this is the velocity at which mixture enters the flame. Calculations for a case are presented, including the effect on flame speed of heating of the central mixture lamina before burning (small), and the effect on flame speed of various assumed increases in flow area in passing through the flame zone. The flame speeds thus computed for the tip appear more realistic when compared to flame speeds determined along the sides of the flame, or by the surface area method. W. T. Olson, USA

2036. **Verschaffelt, J. E., Electrokinetics** (in French), *Acad. roy. Belg. Bull. Cl. Sci.* (5) **38,** 7, 685–694, July 1952.

The mass flow m_v of ions of sort v in an electrolyte is usually written as function of the forces A_μ

$$m_v = \Sigma_\mu \alpha_{v\mu} A_\mu$$

with $\alpha_{v\mu} = \alpha_{\mu v}$ (Onsager's reciprocity relation). The author claims the $\alpha_{v\mu} = 0$, i.e., the action of an electric field on one ion does not depend on the other ions present. L. Meyer, USA

2037. **Popoff, K., On the thermodynamics of irreversible processes** (in French), *ZAMP* **3,** 6, 440–448, Nov. 1952.

In a previous publication [Popoff, AMR **5,** Rev. 2493] it was shown that the Onsager reciprocal relations are first integrals of the set of equations

$$d^2x_i/dt^2 = -\partial(\Delta S)/\partial x_i$$

$$\Delta S = -(1/2)\,\Sigma g_{ik}x_i x_k,\ g_{ik} = g_{ki}$$

Here the x_i represent coordinates, t is the time, and ΔS is the deviation of the entropy of the system from the equilibrium value. In the present paper, a general expression is used for ΔS and it is shown that expressions of the form of the Onsager reciprocal relations hold only in first order. The difference between reciprocal phenomenological coefficients is estimated.

S. S. Penner, USA

2038. **Resler, E. L., Lin, S.-C., and Kantrowitz, A., The production of high temperature gases in shock tubes,** *J. appl. Phys.* **23,** 12, 1390–1399, Dec. 1952.

One-dimensional, unsteady gas dynamics of shock tubes is reviewed with emphasis on approximations for high Mach number, high temperature operation. Discussion and calculations on the effects of nonconstant heat capacities and shock-produced ionization are given for argon. Methods of increasing the sound speed in the initially compressed gas, thus the shock Mach number, include heating the gas on the high pressure side of the diaphragm by external and internal heating elements, internal electric discharge, and by internal combustion. Also use of nonconstant cross section of shock tube is discussed. Preliminary results are given of spectral and electrical conductivity measurements of ionized gas produced by strong shocks with temperatures up to 18,000 K. Reviewer considers paper an important preliminary study of phenomena of high temperature production in shock tubes. H. G. Stever, USA

2039. **Osborne, F. E., High temperature thermodynamic processes,** *Aircr. Engng.* **24,** 284, 294–297, Oct. 1952.

Dissociation of combustion gases at temperatures above 2700 K, such as exist in rocket motors, implies changes in chemical form as working temperature-pressure conditions vary; the usual engineering thermodynamic methods of evaluating cycle performance should be modified to take account of this. A generalized treatment of working processes allowing for change in chemical form is given, and the construction and application of the H-log P diagram is discussed. J. C. Wisdom, Australia

2040. **Roebuck, J. R., On the use of the Joule-Thomson effect to measure the work equivalent of heat. Thermodynamic theory,** *J. appl. Phys.* **23,** 10, 1119–1121, Oct. 1952.

The flow of a fluid through a porous plug under adiabatic-isenthalpic conditions (Joule-Thomson effect) relates pressure and volume changes with the specific heat. As the first are measured in mechanical units and the latter in heat units, these experiments allow a determination of the mechanical equivalent of heat. Author derives the thermodynamic equations for evaluating the mechanical equivalent of heat from Joule-Thomson-effect measurements, and discusses the quantities to be measured and the accuracy required. L. Meyer, USA

2041. **Edse, R., Studies of Bunsen burner flames at high pressures with hydrogen-oxygen mixtures,** Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 441–457, 1952. $6.

The effect of pressure on flashback limits and flame velocities of hydrogen-oxygen mixtures was investigated experimentally. Critical velocity gradients and velocities are reported for the full range of mixture composition at atmospheric pressure and at 14.6 atm, indicating a substantial increase of both at higher pressure. The authors conclude that the velocity of hydrogen-oxygen flames is controlled by heat conduction rather than by the diffusion of hydrogen atoms, as suggested by Tanford and Pease [*J. Chem. Phys.* **15,** p. 861, 1947]. A. K. Oppenheim, USA

2042. **Bloomer, O. T., and Rao, K. N., Thermodynamic properties of nitrogen,** *Chicago, Inst. Gas Technol. Res. Bull.* 18, 28 pp., 2 charts, Oct. 1952. $3.50.

The usual thermodynamic properties of nitrogen have been recalculated on the bases of more recent fundamental data from the published literature. The properties are presented in tabular form and as charts of enthalpy vs. entropy, and of compressibility factor as a function of temperature and pressure. The range of the tables and charts is from saturated liquid at −320.4 F to superheated vapor at 500 F, and pressures from 10 to 1500 psia. Properties tabulated are specific volume, enthalpy, entropy, and the fugacity-to-pressure ratio. For the superheated vapor region, calculations were based on zero-pressure specific heat data and a new equation of state. From authors' summary

2043. **DeZubay, E. A., Influence of hot surfaces on the flame stabilization of a bluff body,** Proc. Sec. Midwest. Conf. Fluid Mech., Ohio State Univ. Press, 459–468, 1952. $6.

Experimental investigation studies the limits of flammability (effective fuel-air ratio) with gaseous fuels, with different burners of bluff body type which also served as flame holders. Local hot-plate surface temperature near burner influences limits; catalytic surface effects (e.g., coating with Fe_2O_3) are noticeable only at low plate temperatures for the rich blowout limit.

Chemical reactor model is not supported by results. Mechanism based on energy balance (heat transfer and flow phenomena) explains trend of tests qualitatively.

H. H. Korst, USA

2044. Clark, D. D., Notes on the derivation of true air temperature from aircraft observations, *Aero. Res. Counc. Lond. curr. Pap.* no. 90, 7 pp., 1 fig., Dec. 1950, published 1952.

Paper describes a simplified procedure for determination of true air temperature from corrected measurements of temperature and pressure as observed on aircraft instruments. By manipulation of the aerodynamic equations, author arrives at an expression for true air temperature involving the indicated temperature, recovery factor, total and static pressure, and ratio of specific heats. Once the indicated temperature and total and static pressure are measured, it is a simple matter to rapidly determine the true air temperature. The method described eliminates the compressibility correction of the standard method and simplifies slide-rule calculations. R. J. Mindak, USA

Heat and Mass Transfer

(See also Revs. 1803, 1901, 1919, 1952, 1985, 2034)

2045. Kampé de Fériet, J., On a class of solutions of the heat equation (in French), *C. R. Acad. Sci. Paris* **234,** 22, 2139–2140, May 1952.

A function $f(x)$ defined for $-\infty < x < \infty$ belongs to Wiener's class S if it is square integrable in each finite interval, and if the autocorrelation $\rho(h|f)$ exists for each h and is continuous for $h = 0$. In this case, $\rho(h|f)$ is the Fourier-Stieltjes transform of the spectrum $S(\lambda|f)$. The author states without proof that, if $f \in S$, then the formal classical solution $u(t, x)$ of the heat equation is a solution such that $u(t,x) \in S$ for fixed t and $u(t,x) \to f(x)$ for almost all t. The autocorrelation $\rho(h|u)$ satisfies the heat equation $\rho_t = 2\rho_{hh}$. Furthermore, author calculates the spectrum of u in terms of the spectrum of f and gives conditions that the former be absolutely continuous, etc.

Courtesy of Mathematical Reviews W. Feller, USA

2046. Barenblatt, G. I., and Levitan, B. M., On some boundary problems for the equations of turbulent heat transfer (in Russian), *Izv. Akad. Nauk SSSR Ser. Mat.* **16,** 253–280, 1952.

The equation of turbulent heat transfer

$$\frac{\partial}{\partial z}\left[A(z)\frac{\partial R}{\partial z}\right] = u(z)\frac{\partial R}{\partial t} \qquad [1]$$

may be put in the form

$$\partial^2 R/\partial x^2 = q(x)\partial R/\partial t, \quad q(x) = u(x)A(z) \qquad [2]$$

by use of the transformation [3] $x = {}_0\int^z [A(z)]^{-1}dz$. If then

$$R(x, t) = y(x, \mu)e^{-\mu^{m+2}t} \qquad [4]$$

the solution of equation [2] is made to depend upon the ordinary differential equation [5] $y'' + \mu^{m+2}q(x)y = 0$. The authors assume that $q(x)$ satisfies the following conditions: (a) $q(x) \geqq 0$ and can vanish only for $x = 0$; (b) $q(x)$ has continuous second derivatives everywhere except possibly for $x = 0$; (c) near the origin $q(x) = x^m(1 + p(x))$, $p(0) = 0$, $m \geqq 0$; (d) ${}_0\int^\infty (q(x))^{1/4}dx = \infty$;

$$\text{(e)} \qquad {}_0\int^\infty \left| \frac{5}{16}\frac{q'^2(x)}{q^{5/2}(x)} - \frac{q''(x)}{4q^{3/2}(x)} \right| dx < \infty$$

With these conditions on $q(x)$, it is shown that the spectrum of the operator $q^{-1}(x)d^2/dx^2$ is continuous. There is also given a generalization of the formula of Poisson which may be used to construct solutions of physical problems associated with Eq. [1] and certain specified boundary conditions. Examples are included to illustrate the case in which the boundary conditions are nonhomogeneous and Eq. [2] is replaced by

$$\partial^2 R/\partial x^2 = q(x)\partial R/\partial t - Q(x, t).$$

Courtesy of Mathematical Reviews C. G. Maple, USA

2047. Hirschman, I. I., Jr., A note on the heat equation, *Duke Math. J.* **19,** 487–492, 1952.

Let $u(x, t)$ satisfy the heat equation

$$\frac{\partial^2 u}{\partial x^2} = \frac{\partial u}{\partial t} \quad (-\infty < x < \infty, \ -\infty < t \leqq c)$$

Appel [*J. Math. pures appl.* (4) **8,** 187–216, 1892] has proved that if $0 \leqq u(x, t) \leqq M$ $(-\infty < x < \infty, \ -\infty < t \leqq c)$, where M is a constant independent of x and t, then $u(x, t)$ must be constant. The principal theorem of the present paper shows that u is constant under weaker assumptions. This is stated as follows. Theorem: Let $(\xi, t) \in \bar{T}$, where $\bar{T}$ is the set of points (ξ, t) with ξ in m-dimensional space and $-\infty < t \leqq c$. If (1) $u(\xi, t) \geqq 0$ for $(\xi, t) \in \bar{T}$, (2) u, u_t, u_{x_i}, $u_{x_ix_i}$ are all continuous for $(\xi, t) \in \bar{T}$, (3) $\sum_{i=1}^m \partial^2 u/\partial x_i^2 = \partial u/\partial t$, $(\xi, t) \in \bar{T}$, (4) $\liminf_{r\to\infty} r^{-1} \log M(r) \leqq 0$, where $r = |\xi|$ and $M(r) \geqq \sup_{|\xi| \leqq r} u(\xi, c)$, then $u(\xi, t)$ is identically constant. This theorem is proved for $m = 3$. Additional theorems giving integral representations of $u(\xi, t)$ under certain specified conditions are also included.

Courtesy of Mathematical Reviews C. G. Maple, USA

2048. Ievlev, V. M., Some questions of the hydrodynamic theory of heat transfer in incompressible flow (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **86,** 6, 1077–1080, Oct. 1952.

Using the impulse and energy equations for turbulent boundary layers and by analysis of experimental data, it is shown that the following approximations hold: $z/z_m \approx 1$; $\alpha = Az^{-n}$, $\alpha m = Bz^{-m_1}z_m^{-m_2}$, where $\alpha = \tau_w/\rho\bar{u}^2$; $\alpha m = q_w/\rho\bar{u}c\bar{t}$, $Re_\vartheta = \rho\bar{u}\vartheta/\mu$; $Re_\theta = \rho\bar{u}\theta/\mu$; $z = Re\vartheta/\alpha$; $z_m = Re_\theta/\alpha_m$; τ_w wall shear stress; q_w specific heat flow; $\bar{u}$ velocity outside the boundary layer; $\bar{t}$ temperature difference between wall and fluid outside the boundary layer; c specific heat; ϑ impulse loss thickness; θ energy loss thickness. For turbulent boundary layers on two-dimensional or axial-symmetrical bodies the following formula then holds

$$z(x) = z(0)[\bar{u}(0)/\bar{u}(x)]^{c_2}[D(0)/D(x)]^{c_1} + c_1 {}_0\int^x [\bar{u}(x_1)/\bar{u}(x)]^{c_2}[D(x)/D(x_1)]^{c_1}[\rho\bar{u}(x_1)/\mu]dx_1$$

D diameter; $c_1 = 1/(1 - n) \approx 1.2$; $c_2 = (1 + H)/(1 - n) \approx 2.7$ with $H = \vartheta/\theta$; for two-dimensional flow, $D(0)/D(x) = 1$ in the above formula; the initial value $z(0)$ must be determined by analysis of the foregoing laminar boundary layer. Having determined z, α and α_m are given by the approximate formulas

$$\alpha = 0.0331\, z^{-0.221} + 4\cdot 10^{-4};$$

$$\alpha_m = (41.5\, z^{0.1692}\, Pr^{0.6} + 35.3\, z^{0.08})^{-1}$$

(calculated from measurements in smooth tubes), and

$$\alpha = 0.0147\,(z/Re_a)^{-0.237} + 4\cdot 10^{-4}$$

(calculated from measurements in rough tubes with $Re_a = \rho\bar{u}a/\mu$ and a = roughness height). W. Wuest, Germany

2049. Ievlev, V. M., Questions in the hydrodynamic theory of heat exchange in gas flow (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **87,** 1, 21–24, Nov. 1952.

An approximate method for the calculation of heat transfer in incompressible flow (see preceding review) is now extended to

compressible gas flow. Similar formulas hold with slight modifications due to compressibility. W. Wuest, Germany

2050. **Yuge, T., Investigation of distribution of the surface heat-transfer coefficients of two-dimensional bodies of various shapes** (in Japanese), *Trans. Soc. mech. Engrs. Japan* **17,** 62, 143–148, Nov. 1951.

Author deals with the solutions of the equations of motion and energy in the laminar boundary layer with pressure gradient along the surface, assuming that the variations of kinematic viscosity ν and thermometric conductivity a are linear with the temperature rise in the layer. For the case $U = c_1x + c_3x^3 + c_5x^5$, equations for the stream function and temperature are solved by double-series expansions in x and temperature coefficient β of ν and a. As an example, heat transfer from a circular cylinder is calculated. Agreement with the existing experimental data is satisfactory. H. Tamaki, Japan

2051. **Sugawara, S., Sato, T., Kadono, A., and Ando, M., Experimental researches on heat transfer at the surface of a flat plate in forced flow, 2nd report** (in Japanese), *Trans. Soc. mech. Engrs. Japan* **17,** 62, 130–136, Nov. 1951.

Heat transfer from a rough plate placed parallel to the uniform flow is measured by the method of the first report [AMR **5,** Rev. 2504]. Roughness considered in this second report consists of parallel rectangular grooves cut in the direction perpendicular to the stream. Results show that, beyond a certain Reynolds number, which depends on the pitch of the grooves, Nu/Re becomes constant, and this value is maximum for a certain pitch of the grooves. H. Tamaki, Japan

2052. **Surinov, Yu. A., Radiant heat transfer in a radiating system consisting of three grey bodies** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 5, 724–748, May 1952.

This mathematical article extends previous work of author [title source no. 7, 1948; nos. 4 and 9, 1950] on general theory of radiative heat exchange between grey bodies to the special case of three bodies. D. ter Haar, Scotland

2053. **Karush, W., and Young, G., Temperature rise in a heat-producing solid behind a surface defect,** *J. appl. Phys.* **23,** 11, 1191–1193, Nov. 1952.

The steady-state temperature distribution in a semi-infinite heat-producing solid which loses heat at the boundary at a uniform rate except in a relatively small insulated region is studied. Explicit solutions are obtained when the insulated region is an infinite strip and a circle. This solution is then used to estimate the temperature rise behind a defect of arbitrary conductance in the highly conducting coating of a heat-producing solid.
W. Squire, USA

2054. **Keyes, F. G., Additional measurements of heat conductivity of nitrogen, carbon dioxide, and mixtures,** *Trans. ASME* **74,** 8, 1303–1306, Nov. 1952.

[See also AMR **5,** Revs. 1216, 4916.] It is now established for the N_2-CO_2 mixtures at low pressure that the sign of the deviation of the observed heat conductivities, relative to the conductivities computed on the basis of the linear composition proportionality, changes, passing from negative at room temperature to zero at about 150 C and becoming increasingly positive at higher temperatures. This behavior is unexpected and appears not to have been hitherto observed. The Enskog theory of the conductivity of mixtures does not predict the observed trend nor does the empirical formula of Lindsay and Bromley. The data have been formulated at each of the three constant concentrations of constituents using the same type of equation that has proved useful for the pure components. The measurement of the pressure effect for the heat conductivities of the N_2-CO_2 mixtures has been attempted but without satisfactory results above 50 C. The difficulty consists of failure of the fluid in the cell to arrive at a steady state above a comparatively low pressure. The cause of the phenomenon is believed to be directly related to the known tendency of the constituents of a mixture to separate in a temperature gradient. From author's summary

2055. **Williams, R. B., and Katz, D. L., Performance of finned tubes in shell-and-tube heat exchangers,** *Trans. ASME* **74,** 8, 1307–1320, Nov. 1952.

Heat-transfer measurements were made for three pairs of tube bundles, with water as the tube-side fluid, and water, lubricating oil, and glycerine as the shell-side fluids. Fluid properties were further varied by operation at several temperature levels. Each pair of bundles included one plain and one finned set of tubes, otherwise identical, with the finned-area/plain-area ratio = 2.07 to 2.76. Shell-side film coefficients were determined from measured over-all coefficients by extrapolation according to the methods of Wilson, and were correlated by $Nu = C(Re)^{0.65}(Pr)^{0.375}(\mu/\mu_w)^{0.14}$ where Nu is Nusselt number, Re Reynolds number based on tube diameter and mean flow rate, Pr Prandtl number, μ viscosity at bulk temperature, and μ_w viscosity at wall temperature. C varied from 0.225 to 0.143, depending upon the bundle. Shell-side coefficients for finned tubes, based on outside area, are roughly 80 ± 20% of those for plain tubes. Pressure drops were correlated by the methods of Donahue, and are less for finned tubes than for plain. R. E. Treybal, USA

2056. **Okazaki, T., On the effect of the air on film condensation, 1st report** (in Japanese), *Trans. Soc. mech. Engrs. Japan* **17,** 62, 161–163, Nov. 1951.

The effect of the air contained in nearly saturated steam condensing on a vertical wall is investigated theoretically. Assuming that the air content is small and the velocity of the steam is the same as that for the case of saturated steam, and using Nusselt's formula for the water film, author gives an approximate solution of the equation of diffusion for the air content. In particular, a formula is derived for the ratio of the air content on the film surface to that of the undisturbed state. This ratio becomes large when the pressure and temperature are low, or when the temperature difference between steam and wall is large.
H. Tamaki, Japan

2057. **Havemann, H. A., Critical cooling,** *Mech. Engr. Bangalore, India* no. 1, 16–25, Oct. 1950.

Paper considers the effect on heat transfer by free convection of using a liquid in its "critical point," the "critical point" being defined in the thermodynamic sense. As a consequence of the increase in specific heat at constant pressure and coefficient of expansion, together with the decrease of viscosity experienced by a liquid at or near its critical point, the heat-transfer rate by free convection should be materially increased. Some experimental evidence is cited to show that this is so. Paper indicates method of using a liquid at its critical point for the cooling of gas turbine blades.

Reviewer believes paper indicates a field where fruitful research might be done. W. A. Wolfe, Canada

2058. **Eisenschitz, R., Transport processes in liquids,** *Proc. roy. Soc. Lond. (A)* **215,** 1120, 29–36, Nov. 1952.

The object of the modern theory is to find the average flow of mass, momentum, or energy, as observed in diffusion, viscous flow,

or thermal conduction, by means of the probability distribution for the coordinates and momenta of a representative molecule or pair of molecules. Transmission of momentum or energy in liquids, as distinct from gases, is due to the action of intermolecular forces.

The probability distribution is determined by a differential equation similar to the equation of Fokker and Planck. Frequently, it is sufficient to find the probability distribution in space coordinates only, by solving the equation of Smoluchowski. These equations apply to the movement of molecules only, invoking a hypothesis of molecular chaos. The friction constants entering as parameters into the differential equations can, in principle, be derived from intermolecular forces; in practice, this involves considerable difficulties.

Even in its present incomplete stage, the theory yields quantitative results comparing reasonably well with experiment.

From author's summary by H. A. Einstein, USA

Acoustics

(See also Revs. 1977, 2005, 2021)

2059. Truesdell, C., Critical length for the propagation of free waves in a viscous fluid (in French), *C. R. Acad. Sci. Paris* **235,** 14, 702–704, Oct. 1952.

Damping formula for sound-wave propagation in viscous barotropic fluids is presented for the case when the Stokes relation between viscosity coefficients ($3\lambda + 2\mu = 0$) is not accepted. (Regarding the controversy of above relation, see *J. rational Mech. Analysis* **1,** 228, 1952, by Truesdell.) From this a critical wave length is computed: $l_c = \pi\mu/\rho V_0$, where $V = 2 + \lambda/\mu$, ρ is density, and V_0 speed of sound. Shorter waves $l < l_c$ are overdamped and do not propagate. The effect of the second coefficient of viscosity (λ) is important for CO_2 for which $V = 2000$ instead of 4/3, which would correspond to the Stokes relation. The critical length for CO_2 is 0.02 cm. For water, $V = 4$ (and not 2 as given in the paper), and $l_c = 10^{-6}$ cm. Limitations of the results recognized by the author are: (1) Some of the critical wave lengths are smaller than permissible within the range of continuum theory which is the basis of the paper, and (2) effect of the heat conductivity is neglected. Reviewer notes that values of V might themselves show frequency dependence [AMR **3,** Rev. 119]. V. G. Szebehely, USA

2060. Schoch, A., Propagation of ultrasonic waves through plates (in German), *Atti Conv. Internaz. Ultracust.* **1950,** 302–306, 1951.

2061. Fox, F. E., Dependence of ultrasonic absorption on intensity and the phenomenon of cavitation, *Atti Conv. Internaz. Ultracust.* **1950,** 198–203, 1951.

At 5 watts/cm², the absorption coefficient is about four times that at low intensity. There appears to be some difference in this effect between water containing air, water containing carbon dioxide, and gas-free water prepared as described, but it has not yet been possible to decide definitely whether this increase in absorption has been caused by cavitation.

From author's summary

2062. Fry, W. J., Mechanism of acoustic absorption in tissue, *J. acoust. Soc. Amer.* **24,** 4, 412–415, July 1952.

Author shows that an absorption mechanism based upon viscous forces acting between a suitably chosen distribution of suspended particles or structure elements and a suspending liquid can account for a linear relationship between the experimentally determined acoustic absorption coefficient in tissue and the frequency in the range of 1.5 to 4.5 megacycles per sec. The range of linearity is dependent upon the distribution limits of the parameters describing the structure elements. Reviewer believes that this paper will be of primary interest to therapy researchers and others concerned with medical applications of ultrasonics. The theory presented here is one of several which are in quantitative agreement with experimental results.

M. S. Weinstein, USA

2063. Furrer, W., and Lauber, A., The importance of sound diffusion in the acoustics of rooms (in German), *Acustica* **2,** 6, 251–255, 1952.

It has become more and more evident in the past few years that the classical quantities are not sufficient to describe adequately the acoustic behavior of a room. In addition to the volume, the reverberation time, and the shape of the room determined by geometrical considerations, the homogeneity of the sound field, which may also be called "diffusion," plays a very important part. It is shown in this paper that the frequency irregularities existing in the stationary state, which have been known for a long time, are not a direct measure for this diffusion. It is possible, however, to prove empirically that the "mean height of a peak" of these irregularities is an important parameter directly related to the homogeneity of the sound field. It is determined—for the frequency regions around 375 cps and 1650 cps—for 11 rooms, whose volumes range from 37 m³ to 20,000 m³.

From authors' summary

2064. Fitzpatrick, H. M., and Lee, R., Measurements of noise radiated by subsonic air jets, *David W. Taylor Mod. Basin Rep.* 835, 27 pp., Nov. 1952.

The spectrum of the acoustic power radiated by turbulent air jets issuing from two nozzles of different diameters was determined over a range of subsonic flow speeds. Results, presented in dimensionless form, show substantial agreement with Lighthill's theory of turbulence noise, which predicts that the ratio of radiated acoustic energy to expended mechanical energy is proportional to the fifth power of the Mach number with only minor dependence upon the Reynolds number. The factor of proportionality was determined to be of the order 2×10^{-4}. This means that, for any given jet, the total radiated acoustic power is approximately proportional to the eighth power of the jet flow velocity. The spectrum exhibits a broad peak, whose frequency appears to be determined by the thickness of the shear layer and the sonic velocity (rather than the flow velocity), but the evidence is not conclusive. From authors' summary

2065. Beyer, R. T., Acoustic relaxation in a van der Waals gas, *J. acoust. Soc. Amer.* **24,** 6, 714–715, Nov. 1952.

An expression given by O. Nomoto [*Bull. Kobayasi Inst.* 1, 162, 1951] for the sound velocity in a van der Waals gas is corrected; also the absorption coefficient per unit wave length in such a gas is derived. Numerical evaluation of the formulas obtained shows that, except at very high pressures, the van der Waals correction to acoustic relaxation is hardly detectable by experiment.

F. E. Borgnis, USA

2066. Siegert, A. J. F., On the evaluation of noise samples, *J. appl. Phys.* **23,** 7, 737–742, July 1952.

Paper develops statistical tests to aid in decision as to whether a sample of noise can be assumed to have come from a Gaussian distribution. Tests are based upon distribution function of lower bounds of sample during test interval. This function is compared in a probabilistic manner with that of a given Gaussian distribution. T. Caywood, USA

2067. **Morse, R. W., Acoustic propagation in granular media,** *J. acoust. Soc. Amer.* **24,** 6, 696–700, Nov. 1952.

The macroscopic approach is used to obtain information about elastic wave propagation in a granular medium. The theory developed for the velocity of sound and attenuation coefficient seems in excellent agreement with existing experiments when the particle size is uniform. Frequency dependencies are observed.

K. M. Siegel, USA

2068. **Neuringer, J. L., and Hudson, G. E., An investigation of sound vibrations in a tube containing a heat source,** *J. acoust. Soc. Amer.* **24,** 6, 667–674, Nov. 1952.

Using linearized theory of standing sound waves in a tube containing a heat source, through which air is blown, authors show that excitation of the fundamental tone will occur when the heat transfer depends on the gradient of the air speed. This dependency is attributed to an increased turbulence at places with higher speed. In that case, the heat transfer would increase in a negative velocity gradient. Excitation is then possible only when the heater is located in the first half of the tube. This is in accordance with experience.

It is not clear to reviewer how the intensity of turbulence can adjust itself to the rapid velocity changes in a sound wave at a few hundreds of cycles. L. F. J. Broer, Holland

2069. **Osborne, D. V., Propagation of second sound below** 1° K, "Low-temp. Physics," *Nat. Bur. Stands. Circ.* 159, 139–144, Oct. 1952.

Author describes the observations in detail for the measurement of the velocity of second sound in liquid helium II below 1 K. The technique consists in sending a direct current pulse of duration 100μ sec into a constantum heater at one end of a glass tube, and amplifying the signal received by a phosphor-bronze resistance thermometer at the other end of the tube and displaying it on a cathode-ray tube. Four oscillograms of the temperature-received pulses at 0.44, 0.48, 0.54, and 0.60 K, respectively, are given which show the increase in velocity with the fall in temperature. The author, in collaboration with Atkins, has shown in one of his earlier papers that the velocity reaches 152 ± 5 m/sec at 0.1 K. These results, as a matter of fact, confirm the earlier observations of Peshkov, Maurer and Herlin, and Pellam and Scott.

G. S. Verma, India

2070. **Barone, A., Optical method for measuring velocities of longitudinal and transverse ultrasonic waves in solids** (in Italian), *Atti Conv. Internaz. Ultracust.* **1950,** 135–143, 1951.

See AMR **4,** Rev. 4314.

Ballistics, Detonics (Explosions)

(See also Rev. 2018)

2071. **Biggeri, C., New general methods in rational ballistics** (in Spanish), *Univ. nac. La Plata, Publ. Fac. Cienc. Fisicomat.* (2), **4,** 4, 314–351, Dec. 1951.

Paper deals with the integration of the classical system of differential equations governing the ballistic trajectory of a non-lifting shell. The equations are considered in the most general form: The dependence of density, temperature, and acceleration of gravity on altitude, and the effect of compressibility on the drag are taken into account.

Previous methods are discussed and criticized. Emphasis is placed on the mathematics rather than on the physics of the problem. After convenient transformation, the final solution is obtained through a succession of recurrent integrations.

Substantially, this paper is a contribution to the analytic theory of ordinary differential equations. In reviewer's opinion, Biggeri's article has considerable mathematical interest.

A. Miele, USA

2072. **Brändli, H., Barrage firing of small-caliber anti-aircraft defense, taking into account errors in the firing data** (in German), *Flugwehr und Technik* **14,** 9, 10, 11; 203–207, 223–228, 249–253; Sept., Oct., Nov. 1952.

Author continues his investigation of this type of barrage firing [AMR **5,** Rev. 2735] and now studies the influence of errors in range, speed, and angle of course of the target, and the influence of the duration of each barrage fire.

Theoretically and graphically he deduces the limits of the "relative speed error" giving effective barrage. He proves that the speed introduced in the computer must be greater than the actual speed of the target. Up to 50% excessive valuation is often advisable.

An error in determining the angle of course is of no great importance at angles between 70° and 90°, but very important at small angles of course. The results are shown graphically. The delay, before the gun stops in position for the barrage, is caused by the layer's time of reaction and by the inertia of the gun. This delay is one of the reasons for excessive valuation of the speed.

The duration of the barrage and its influence on the efficiency are thoroughly investigated. Author arrives at a duration between $^1/_2$ and $1^1/_2$ sec.

Author finally suggests that these investigations might possibly be applicable to a study of barrage firing with small antiaircraft rockets. R. Sjöberg, Sweden

2073. **Kooy, J. M. J., Some problems of interplanetary travel** (in Dutch), *Ingenieur* **64,** 46, L.37–L.45, Nov. 14, 1952.

Author examines possibilities of using multistage rockets for setting up satellites or for escaping gravitational field of earth with existing technical and chemical means. Some optimal problems are discussed and some aspects are given of a flight around the moon. After brief description of von Braun's 7000-ton project, stability conditions are discussed for motion of a space station, describing a circular orbit around earth at a short distance.

Reviewer draws attention to a few misprints: In the table, the two last C-values should read 5000 and 10,000 instead of 50,000 and 1000; in first equation, right side of page L38, m should be cancelled. S. F. Erdmann, Sweden

Soil Mechanics, Seepage

✎2074. **Peck, R. B., Hanson, W. E., Thornburn, T. H., Foundation engineering,** New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1953, xix + 410 pp. $6.75.

The purpose of this book is to supply an adequate textbook for the teaching of foundation engineering to undergraduate students. An attempt has been made to combine the art of engineering design and the theories of engineering science into one coherent presentation. Soil mechanics is included when applicable to problems in foundation design. Other aspects of soil mechanics (such as seepage in dams) have been omitted.

The book is divided into four main sections: (A) Properties of subsurface materials; (B) types of foundations and methods of construction; (C) selection of foundation type and basis for design; (D) structural design of foundation elements. Part A deals with the fundamentals of soil mechanics, geology, and soil exploration. Part B describes the various types of construction

which are common in engineering practice. Part C discusses advantages and disadvantages of various construction types with respect to types of soil. The last section is a course in design. Numerous design plates give the last two sections somewhat of a case-method approach.

Authors stress the importance of engineering experience and art, which make up a large part of foundation engineering.

Reviewer believes that this book has an excellent approach to the teaching of foundation design, and that other fields of design instruction would do well to follow this lead in future textbooks on design. J. A. Cheney, USA

2075. Kastner, H., On the theory of the true mountain pressure in rock cavities (in German), *Öst. Bauzeitschr.* **7,** 6, 94–101, June 1952.

This paper is an attempt to discuss a rational basis on which the study of phenomena connected with mountain pressure in tunnels could be founded. The necessity of taking into account zones of plastic strains about the cavities is especially pointed out. Finally, the phenomenon of landslip is discussed from this standpoint. D. Radenković, Yugoslavia

2076. Nazarov, V. V., A simplified method for calculating the stability of earth slopes (in Russian), *Gidrotekh. Stroit.* no. 11, 28–30, Nov. 1952.

A method of analysis of stability of cohesive earth banks is presented, purporting to simplify the existing methods and supposedly providing a fair and safe agreement with them. The method is based on replacement of soil cohesion by an equivalent negative surcharge over the free surface, and considering the free face of the earth slope as the back of a retaining wall subjected to pressure of cohesionless material. No reason for the procedure is given, and, in the opinion of the reviewer, it is completely arbitrary and unjustifiable. A. Hrennikoff, Canada

2077. Simakov, I. M., Method for finding the most dangerous sliding curve in calculation of stability of slopes (in Russian), *Gidrotekn. Stroit.* no. 8, 33–36, Aug. 1952.

There are several graphical and semigraphical methods for determining the stability of slopes, based on assumed sliding arcs. A construction is presented which yields a solution for the minimum coefficient of stability of the slope with fewer trials than the usual methods. The assumed sliding surface used is circular.

M. W. Jackson, USA

2078. Dervieux, F., Compacting of soils (in French), *Ann. Inst. tech. Bât. Trav. publics* **5,** 52/53, 449–460, Apr./May 1952.

Paper is addressed to contractors bidding for the construction of embankments where the specification requires the final compaction of the soil to approach the maximum dry density obtained by a "standard" compaction test. It urges the need for a careful study of the soils available so that an accurate estimate may be made of the cost to the contractor of meeting the specification. The paper outlines the basic information required for such a study, and deals, in succession, with the physics of soil compaction, the use of "Proctor" curves, the importance of knowing the plastic range of the soil, its shrinkage limit, its moisture content when in the borrow pit, and the performance of the compaction plant available. The most widely used standard compaction tests are then discussed, and the warning is given that some of them are very severe, requiring field compaction to be carried out in thin layers with very heavy plant. The author has drawn largely upon his experience of road construction in Algeria.

T. Lonsdale, England

2079. Nishida, Y., On the supporting power of a foundation pile by friction (in Japanese), *Trans. Soc. civ. Engrs. Japan,* 13, 31–35, Mar. 1952.

Starting from the fundamental equations of a perfectly elastic body, author presents a theory of the foundation pile. The satisfaction of the friction law around a pile and the linear increase of the normal stress with the depth are assumed, but the end condition at the tip of the pile is not considered. The bearing capacity of the pile is determined from the condition that the critical state against friction should be satisfied when the load acting on the pile is increased. Comparisons with experiments or field data are not presented. T. Mogami, Japan

2080. Ohde, J., On the theory of earth pressure (in German), *Bautechnik* **29,** 8, 219–224, Aug. 1952.

Article is continuation of series on earth-pressure theories [AMR **5,** Revs. 1571, 2740], and deals with classical theories of active and passive pressures on walls with movement by rotation about the base. Usual graphical methods of analyzing retaining-wall problems with and without surcharge are described, using approximate plane rupture surfaces.

G. G. Meyerhof, England

2081. Ohde, J., On the theory of earth pressure (in German), *Bautechnik* **29,** 11, 315–318, Nov. 1952.

This fourth article of the series (see preceding review) deals with distribution of active earth pressure on walls due to concentrated and distributed surcharges on backfill. Method is based on usual incremental determination of the pressure using plane slip surfaces, which are only sufficiently accurate in practice if the wall tilts around its base. G. G. Meyerhof, England

2082. Sokolovskiĭ, V. V., On the limit equilibrium of granular media (in Russian), *Prikl. Mat. Mekh.* **15,** 6, 689–708, Nov./Dec. 1951.

Author considers only particular conditions when granular medium has an internal friction but does not have cohesion. By employing the theory of limit equilibrium, solutions of such problems are obtained in a simpler manner as compared with the application of the general theory, which was previously described by author in his book, "Statics of granular media" ("Statika sypuchey sredy," Akad. Nauk SSSR, 1942).

Problems in which zones of the limit and elastic states exist simultaneously can be treated by this method, too. Solutions of these problems are either in a closed form or they lead to an integration of ordinary nonlinear equations. Author derives equations of the limit equilibrium in polar coordinates. Stress states of a granular wedge are investigated for the cases when the angle at the apex is larger or smaller than 180°. Author also considers a problem of stability of a granular wedge and the foundation, and a problem of pressure distribution on the retaining wall produced a granular body. V. A. Valey, USA

2083. Loudon, A. G., The computation of permeability from simple soil tests, *Géotechnique, Lond.* **3,** 4, 165–183, Dec. 1952.

Paper relates a series of experiments on the permeability of sands. Measurements are intended as a check of some of the more important formulas for calculating the Darcy coefficient from the geometrical properties of granular material (porosity, particle size, etc.). Kozeny's well-known formula showed the best agreement with the tests. Author also suggests a new formula, akin to that of Kozeny but somewhat more adapted to practical use.

P. Wilh. Werner, Sweden

2084. **Gurr, C. G., Marshall, T. J., and Hutton, J. T., Movement of water in soil due to a temperature gradient,** *Soil Sci.* **74,** 5, 335–345. Nov. 1952.

The effect of a temperature gradient on the movement and distribution of water in soil has been examined in closed columns of soil for a wide range of initial water content. Small amounts of soluble salts acting as a tracer serve to distinguish between liquid and vapor movement. It was assumed that movements of the soluble salts were due to transport in the liquid phase only. In all except the wettest and driest columns of soil there was a transfer of water toward the colder end of the column and of salts toward the hotter end. In ten columns of loam soil having initial water contents ranging from 1.7 to 24.5%, there was a net transfer of water in all columns except the driest toward the colder end of the columns, and of chlorides toward the hotter. This net transfer of water from hot to cold is thought to be due to the movement of water in the vapor phase from the hotter soil into colder soil, where it condenses and returns as a liquid when a favorable gradient of pressure potential has been established. It is shown from theoretical considerations that, when the soil is sufficiently wet to permit liquid flow, a state of equilibrium cannot be reached and continuous circulation of the water takes place. The maximum net transfer of water in the loam soil from the hot to the cold end over a five-day period occurred in columns having initial water contents of 5.3 to 7.9%, or approximately 1/5 of the moisture equivalent.

The concentration of salts at the hot end sets up an osmotic potential gradient favoring liquid movement to the hot end. However, on two sand columns in which a strong osmotic potential was established favoring liquid flow in the direction hot to cold, the resulting net transfer of water to the cold end still occurred as in the loam soil. This showed that liquid moved toward the hot end irrespective of the direction of the osmotic potential gradient. Even though the variable salt concentrations affected the vapor pressure and, hence, the movement of vapor, these effects were of only a minor order in the present experiments, in comparison with the effect of temperature on vapor pressure. It is of considerable interest that appreciable movement of water as a liquid occurred in the loam soil as dry as 7.9%, which corresponds to a pressure potential of approximately -0.8×10^7 ergs/gm, which is equivalent to a pF of 3.9. The use of soluble salts to distinguish between liquid and vapor flow in soil appears to be very useful. The reviewer suggests that a radioactive tracer element might be used in place of the salt with even more success. V. E. Hansen, USA

2085. **Mori, A., On the electric conductivity of soils** (in Japanese), *J. Soc. civ. Engrs. Japan* **36,** 11, 13–17, Nov. 1952.

Results of experimental studies on the electric conductivities of soils, loam, and bentonite saturated with water are presented. Author studies the conductivity as consisting of two kinds, one of which is the ionic conductivity and the other is that which is due to the conductivity along the surfaces of soil particles. The results are applied to estimate the average change in diameters of pores of soil when the moisture content varies. Effects of temperature are not considered. T. Mogami, Japan

Micromeritics

2086. **Petersen, E. E., Walker, P. L., and Wright, C. C., Mathematical analysis of size-frequency distributions of particles in the subsieve range,** *ASTM Bull.* no. 183, 70–75, July 1952.

A method is proposed for calculating surface area and weight distributions from microscopic size-frequency measurements wherein the necessity of assuming a mean diameter to represent the size interval has been obviated. This method permits the microscopic classification of particles into broader intervals than currently recommended, thereby reducing the time consumed in counting particles, especially when the sample contains a wide range of sizes.

A statistical analysis of count data for coal samples with sizes ranging from 1 to 100μ indicates that the reproducibility is sufficient to warrant calculations on the basis of the above method.

From authors' summary by N. G. Blomqvist, Sweden

2087. **Pinkus, O., Pressure drops in the pneumatic conveyance of solids,** *J. appl. Mech.* **19,** 4, 425–431, Dec. 1952.

Measurement of total pressure drop of fully developed turbulent air flow carrying sand in a round pipe shows that additional pressure drop due to sand increases linearly with both air-flow rate and sand-flow rate. No report is given of velocity field or sand distribution.

Author's "theoretical prediction" of these linear variations seems just an immediate consequence of ad hoc algebraic form he assumes as "Fanning equation" (see also Darcy, Chezy, etc.) for sand flow.

Fairly detailed theoretical analysis of gross particle dynamics (with averaging not even mentioned), incorporating Fanning factor, leads to prediction of terminal ratio of mean sand velocity to mean fluid velocity. Comparison with experiment yields obvious conclusion that particle drag coefficient depends on particle Reynolds number, even in turbulent fluid. This is noteworthy because it contradicts an obviously erroneous statement by Dalla-Valle ["Micromeritics," Pitman Corp., 2nd ed., 1948, chap. 2, p. 40]. S. Corrsin, USA

2088. **Mints, D. M., On the hydrodynamic resistance of a granular layer suspended in a flow** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **83,** 4, 541–544, Apr. 1952.

For flow through a fluidized bed, the resistance coefficient is defined as $\eta = (\Delta p m^3)/[L\rho u^2\omega(1 - m)]$ and Reynolds number as $Re = \rho u/[\mu\omega(1 - m)]$, where $\Delta p/L$ is the pressure drop per unit bed thickness, ρ the fluid density, u the flow velocity, μ the fluid viscosity, m the bed porosity, and ω the particle surface area per unit bed volume. By a semi-empirical consideration of limiting conditions, the correlation $\eta = c_2 + C_1/Re$ is proposed and checked by experimental data. The dependence of resistance on porosity is also investigated similarly. N. A. Hall, USA

Geophysics, Meteorology, Oceanography

(See also Rev. 1817)

2089. **Bushby, F. H., The evaluation of vertical velocity and thickness tendency from Sutcliffe's theory,** *Quart. J. roy. meteor. Soc.* **78,** 337, 354–362, July 1952.

The author presents a mathematical equation for calculating the large-scale vertical velocity and the consequent rate of change of thickness of an isobaric layer. The method is based on a model of the atmosphere in which the vertical wind shear is in the same direction at all heights. The basic equation is essentially an expression of the fact that the vorticity equation must be satisfied at all heights; that the net divergence from a vertical column is approximately zero; and that the changes of temperature by advection and vertical motion must be consistent with hydrostatic requirements.

Since quasi-geostrophic motion is assumed, it is possible to compute the vertical velocity from a knowledge of the contours of a selected isobaric surface and the thickness of an isobaric layer

representative of the troposphere. The author presents the results of such calculations in six synoptic situations, using for basic data the contours of the 600-mb surface and the thickness of the 1000–500-mb layer. To verify the validity of the calculation, he computes the rate of change of 1000–500-mb thickness and compares this with the observed thickness tendency. Agreement is reasonably satisfactory considering that instantaneous tendencies have to be compared with observations at 6-hr intervals.

The numerical work involved in these calculations is very heavy and, unless electronic methods are used, only a few such calculations can be carried out. However, this is probably the first practical method of calculating the field of vertical velocity which requires as basic data only those variables normally presented on prognostic charts, viz., the horizontal fields of pressure and temperature. J. S. Sawyer, England

2090. Inoue, E., Turbulent fluctuations in temperature in the atmosphere and oceans, *J. meteor. Soc. Japan* **30,** 9, 289–295, Sept. 1952.

From theoretical considerations, author arrives at possible mathematical expressions for the intensity of temperature fluctuations at a point, and for the magnitude of temperature differences between two points; also for the autocorrelation coefficient for temperature at a point as a function of time, and the correlation coefficient between temperatures at two points as a function of the distance between the points.

Alternative expressions for each of the above parameters are derived, one based on the author's own work, the other on work of several Russians, particularly Obukhov. Methods of testing the alternatives for correctness are suggested; one such method is followed through with results the author believes favorable to his own hypothesis. The data presented are not convincing.

The work is mathematically ingenious, but, as with most theories of turbulence, is based on conceptual models that may or may not prove to be of value in the long run.

F. I. Badgley, USA

2091. Carr, J. H., and Stelzriede, M. E., Diffraction of water waves by breakwaters, "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 109–125, 1952. $1.75.

See AMR **5,** Rev. 3595.

2092. McNown, J. S., Waves and seiche in idealized parts, "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 153–164, Nov. 1952. $1.75.

Waves excited in an almost completely enclosed circular harbor by forced waves in the ocean outside, are investigated in a large model and shown to be in good accord with results of a simple mathematical analysis. H. Stommel, USA

2093. Haque, S. M. A., The initiation of cyclonic circulation in a vertically unstable stagnant air mass, *Quart. J. roy. meteor. Soc.* **78,** 337, 394–406, July 1952.

Equations of motion are derived in cylindrical coordinates and are applied to study the perturbation in a vertically unstable stagnant air mass having infinite lateral extent and confined between two horizontal planes. A solution of the perturbation equation with certain boundary conditions is derived. The boundary conditions are then varied by surrounding and surmounting the unstable air mass with stable air. It is shown that the horizontal extent of the unstable air mass has a definite upper limit which depends on the magnitude of instability, height of the disturbance, and the Coriolis parameter. The resultant mathematical analysis is then applied to show that a tropical cyclone may originate from vertical instability. Author concludes, by a numerical illustration, that the distribution and the order of magnitude of different weather elements are the same in the mathematical model as observed in the initial stages of a tropical cyclone.

Reviewer believes that the distribution and order of magnitude of weather elements are rather similar to the model as observed in the *mature* stage of a tropical cyclone, not in the *initial* stage. He also believes that too many misprints in mathematical expressions are misleading for readers. H. Arakawa, Japan

2094. Gutenberg, B., SV and SH, *Trans. Amer. geophys Un.* **33,** 4, 573–584, Aug. 1952.

The motion of the ground at the earth's surface under the action of incident sinusoidal transverse waves (*S*-waves) is discussed. For this purpose the incident *S*-wave is resolved in a horizontal component (*SH*) and a component in the plane of propagation (*SV*). Several relations between these components and the ground displacement are derived and numerically discussed. Equations are given in order to find, from the recorded *S*-waves, the amplitudes of the incident *SV*- and *SH*-waves and the polarization of the *SV*-waves. A number of applications to actual records made at Pasadena, Calif., with various instruments are discussed. H. L. Oestreicher, USA

2095. Petterssen, S., On the propagation and growth of jet-stream waves, *Quart. J. roy. meteor. Soc.* **78,** 337, 337–353, July 1952.

Essentially, paper discusses propagation of Rossby type of waves in a barotropic zonal current with slower moving air on either side. Variation of rotation with latitude is included but is not found important. Argument centers round calculating the velocity of propagation of a train of waves and the distortion and growth of wave form, and illustrates a mechanism for the latter.

For forecasting purposes, the difficulty of measuring the wave length is almost insuperable, and no short cut to the advection of vorticity by wave-length methods seems likely.

R. S. Scorer, England

2096. Ergin, K., Energy ratio of the seismic waves reflected and refracted at a rock-water boundary, *Bull. seism. Soc. Amer.* **42,** 4, 349–372, Oct. 1952.

Using the Zoeppritz and Blut equations as well as Snell's law, the energy ratio for reflected and refracted waves is tabulated. The results for different numerical values of the parameters σ, Poisson's ratio, $m = v_{1p}/v_{1s}$, $n = v_{2p}/v_{1p}$, and $r = \rho_2/\rho_1$ are represented in 15 tables and 10 figures. In the case of the ocean floor, the general behavior, zeros, and extreme values of energy ratio are most influenced by the first parameter; n plays an important part around the critical incidence. Certain other conclusions are also drawn from these tables.

W. S. Jardetzky, USA

2097. Platzman, G. W., Some remarks on high-speed automatic computers and their use in meteorology, *Tellus,* **4,** 3, 168–178, Aug. 1952.

The main features of the logical framework of a digital electronic computer is described, and a simple computation problem is proposed to illustrate the steps leading to formulation of other problems for machine computation. As high-speed computers are available, the different forecasting problems in meteorology can now be approached by applying strict hydrodynamic and thermodynamic equations. Subject headings: (1) Numerical integration. (2) High-speed computer. H.-L. Kuo, USA

2098. **Byerly, P., Theory of the hinged seismometer with support in general motion,** *Bull. seism. Soc. Amer.* **42,** 3, 251–261, July 1952.

Paper develops a more complete theory of the seismometer by taking into consideration the rotations of the support and the accelerations at right angles to the principal forcing acceleration. Main purpose of the paper is to establish conditions under which the ordinary, simplified, theories are applicable. These conditions are explicitly given in the form of seven inequalities.

H. L. Oestreicher, USA

2099. **Darbyshire, J., The generation of waves by wind,** *Proc. roy. Soc. Lond.* (*A*) **215,** 1122, 299–328, Dec. 1952.

This paper summarizes a study of many ocean wave spectra. Height and period of most energetic component, longest period present, total wave energy, and shape of spectrum are all believed to be determined largely by wind speed in the generating area, provided the fetch is over 100 mi. Influence of limited fetch, down to 1 m, is also studied. Formulas and curves are given, but the observational points tend rather to fill areas than to lie closely along curves. Reviewer considers presentation of these areas the most important content of paper. Observations on attenuation and group velocity, and physical theory are also discussed.

P. Rudnick, USA

2100. **Neumann, G., On the complex nature of ocean waves and the growth of the sea under the action of wind,** "Gravity waves," *Nat. Bur. Stands. Circ.* 521, 61–68, Nov. 1952. $1.75.

About 250 sets of observations are summarized for crest-to-crest "period" in a fully developed sea, at wind speeds from 2 to 22 m/sec. Histograms for these periods are reported to be trimodal, the longest period corresponding to wave phase velocity 1.37 times wind velocity. (See preceding review, where a maximum ratio 1.00 is derived from true spectra.) Results of semi-empirical analysis are briefly stated. Calculated fetches are somewhat shorter than those of Sverdrup and Munk [*USN Hydrographic Office Pub.* no. 601, 1947]. P. Rudnick, USA

2101. **Putz, R. R., Statistical distributions for ocean waves,** *Trans. Amer. geophys. Un.* **33,** 5, 685–692, Oct. 1952.

Results are presented from the analysis of data obtained by underwater pressure recorders in the Pacific Ocean. Computed parameters describing the statistical distribution of wave heights and wave periods are given and incorporated into one-parameter probability models closely fitting the data. The model for wave-height distributions is found to provide a satisfactory explanation for the ratios among the mean and certain specified wave heights reported by other observers. The degree of relation between the heights or periods of successive waves or between the height and the period of the same wave was found to be relatively low. From author's summary

2102. **Corkan, R. H., and Doodson, A. T., Free tidal oscillations in a rotating square sea,** *Proc. roy. Soc. Lond.* (*A*) **215,** 1121, 147–162, Nov. 1952.

This subject has been studied by many investigators, but solutions have not been adequately illustrated numerically, and some of the solutions have been limited to slow rotations. The use of iteration methods for a square sea indicated the possibility of covering a wider range of rotations and of exploring the use of such numerical methods in tidal problems where the interactions of tides in two phases offer unusual complications. In the case of a square sea, these interactions only needed special consideration at the boundary. The investigation has been extended to throw light on the use of the energy equation to specify free oscillations, commonly referred to as Rayleigh's principle but adapted to rotating seas, and simpler solutions of well-known period formulas have been obtained.

From authors' summary by H. J. Schoemaker, Holland

2103. **Vick, F., On sedimental material transport in tide rivers** (in German), *Wasserwirtschaft* **43,** 1, 10–13, Oct. 1952.

Comparison of ebb and flow tides on transport of materials in tidal waters is treated briefly. It includes empirical analysis based on material transport varying as $(\text{velocity})^n$.

J. M. DallaValle, USA

2104. **Ogura, Y., A supplementary note on the problem of ice formation,** *J. meteor. Soc. Japan* **30,** 7, 231–239, July 1952.

A formula representing the speed of the growth of ice layer is derived theoretically. A fairly good agreement between the values computed by means of this formula and the experimental data obtained by K. Neumann [*Ann. Meteor.* **2,** 5/6, 144–155, 1949] is shown graphically. The heat transfer from the surface of ice into the air is also explained, taking into consideration the existence of a turbulent boundary layer near the surface.

H. Arakawa, Japan

Lubrication; Bearings; Wear

(See also Rev. 1919)

2105. **Cameron, A., Hydrodynamic theory in gear lubrication,** *J. Inst. Petrol.* **38,** 344, 614–622, Aug. 1952.

Paper attempts to explain the operation of gears on the basis of hydrodynamic forces involved. Analysis and experiment are based on simulation of gear operating conditions by sliding and rolling of edge of a disk on the face of another with axes crossed. Test equipment permits measurement of speed, friction, and normal load. Experimental results indicate coefficient of friction is sensibly independent of speed until scuffing occurs at some critical speed.

Theoretical analysis first considers rigid disks and constant oil viscosity. Discrepancies between theory and test are considered, and effects of pressure viscosity, film temperature variation, and elastic surface deformations are noted. These considerations provide improved qualitative agreement with experiment.

Reviewer suggests that steady-state operating conditions at point of contact in test equipment may not produce the same effect as constantly changing relative values of rolling and sliding experienced by gear contact. Importance of hydrodynamic forces probably also is not so great where thin films and high rubbing speeds exist. Under these conditions, lubricant properties and additive composition predominate in importance.

J. B. Bidwell, USA

2106. **M'Ewen, E., The effect of variation of viscosity with pressure on the load-carrying capacity of the oil film between gear-teeth,** *J. Inst. Petrol.* **38,** 344, 646–650, Aug. 1952.

Author thinks that hydrodynamic lubrication of gear teeth is possible, and he attempts to calculate the minimum film thickness. He uses Reynolds differential equation for the pressure in an oil film and assumes that there is no side leakage. Next, assumption is made with an expression for viscosity-pressure dependence containing two arbitrary constants. Author concludes that "for surfaces of sufficiently high finish" the maximum of the hydrodynamic zone increases as the two-thirds power of relative radius of curvature. R. Schnurmann, England

2107. Macks, E. F., Nemeth, Z. N., and Anderson, W. J., Predicting operating temperatures of high speed cylindrical roller bearings, Prod. Engng., Annual Handbook of Prod. Design for 1953, F2-F6.

Paper gives an empirical formula which enables the designer to specify size, speed, load, and lubrication requirements, so that bearing operating temperature will fall within safe limits.

From authors' summary

2108. Schallamach, A., The load dependence of rubber friction, *Proc. phys. Soc. Lond. (B)* **65,** part 9, 393B, 657–661, Sept. 1952.

It is shown experimentally that the load dependence of rubber friction can be explained as being due to the load dependence of the true area of contact between rubber and track if the surface asperities of the rubber are assumed to be hemispherical.

From author's summary

Marine Engineering Problems

(See also Rev. 2006)

2109. Yeh, G. C. K., and Ruby, W. J., A new method for computing keel block loads, *Soc. nav. Arch. mar. Engrs.*, 27 pp., Nov. 1952.

Paper gives an analysis of bending deflections of a ship considered as a free-free beam supported by elastic foundation consisting of wooden blocks resting on a concrete base. The purpose of the analysis is to determine the load distribution on keel blocks which support the ship after the graving dock is pumped free of water.

Foundation modulus or force per unit deflection per unit length of beam is supposed constant at each point along the keel. This definition of elastic support is in accord with the viewpoint expressed elsewhere by Hetényi ["Beams on elastic foundation," Univ. Mich. Press, Ann Arbor, Mich., 1946.] The differential equation of equilibrium is then in the form

$$[EIw_{xx}]_{xx} + K(x)\cdot w = q(x)$$

Equation of equilibrium is solved, subject to given boundary conditions, by the energy method of Ritz [*Crelle Journal*, **135,** 1908]. The assumed shape functions are those for the normal modes of vibration of a uniform free-free beam. The coefficients in the series defining the deflections were determined for the first five modes only.

Paper is significant for the extensive analysis of dry-docking data for passenger liner *America* provided by Newport News Shipbuilding and Dry Dock Company. Results are given in the form of curves of moment of inertia of ship section, foundation modulus variation, deflection, and keel block load.

Authors emphasize that they are primarily illustrating an analytical tool for naval architects. Notwithstanding this, reviewer thinks that some consideration should have been given to the degree of convergence of the approximation. Also, the question of lower bounds by method of finite differences might profitably have been treated. Such observations apply particularly in these times when approximate methods and numerical calculations are so much in vogue.

W. H. Hoppmann, II, USA

2110. Edstrand, H., The influence of draught on propulsive qualities (in Swedish), *Medd. SkeppsProvAnst. Göteborg* no. 21, 20 pp., 1952.

Model of cargo ship of 3900-ton displacement and with block coefficient 0.732, having speed in calm water of 12 knots with 1000 shp and 130 revs/min, was tested on three different drafts on even keel and a fourth draft with propeller just submerged and considerable trim corresponding to trial-trip ballast condition. Results agree with other similar tests. Power-revolution curves coincide for different drafts on even keel as long as propeller is fully submerged, only somewhat higher revolutions with corresponding higher power are needed with deeper draft. Trial trip condition is favorable.

G. Vedeler, Norway

2111. Turnbull, J., The longitudinal strength of ships, *Engineering* **174,** 4523, 4524: 449–450, p. 483; Oct. 3, Oct. 10, 1952.

Paper is a much abridged summary of results from several full-scale investigations of ship strength performed under direction of Admiralty Ship Welding Committee. These investigations have been conducted to throw light on the quasi-empirical basis of traditional ship structural design. Some results referred to in this paper have already been published in *Trans. INA* [**88,** p. 78, 1946; and **91,** p. 29, 1949], but other results are not as yet published. Five major results are described: (1) Observations of wave form were made on *Ocean Vulcan*, a welded dry-cargo ship 416 ft long, during eight double crossings of the North Atlantic. Results indicate that ratio of wave height to wave length is closer to $^1/_{12}$ rather than the $^1/_{20}$ assumed for the standard trochoidal wave commonly selected for longitudinal strength calculations. From the observations it was deduced that, in long ships, stress computed from classical theory would be higher than that actually experienced, and lower in short ships. From strains measured during the ocean voyages, it was also concluded that horizontal bending and torsion may be neglected when computing longitudinal stresses, but effects of axial thrust and of slamming must be considered.

(2) Other separate investigations comparing welded with riveted ships indicate that, in still water, there is no significant difference in deflection. Furthermore, little evidence exists that the rivets slip.

(3) From strains measured during static hogging and sagging tests, the "heart-of-plate" stresses follow simple beam theory. However, departures existed at longitudinal stiffeners where the strains are higher than given by elementary theory, particularly if plating is not fair. Undesirable concentrations of local stress due to longitudinal bending are more severe, however, in a transversely framed ship.

(4) Using a statistical strain gage on the *Ocean Vulcan*, observations were made of 275,000 alternations of strain. Only two observations were above 6 ton/sq in., and 109 above 4 ton/sq in. It was thus concluded that, in ship design, consideration need not be given to fatigue of metals.

(5) Paper concludes with usual comment on importance of proper distribution of cargo and "desirability of using in welded construction good ductile notch tough steel—especially for deck plating."

Reviewer believes paper is excellent summary of full-scale strength investigations, but since results which support conclusions are absent, paper should be further expanded by reference to original publications.

E. Wenk, USA